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INDUSTRIAL RADIOGRAPHY COURSE, INSTRUCTORS' GUIDE. VOLUME 2.

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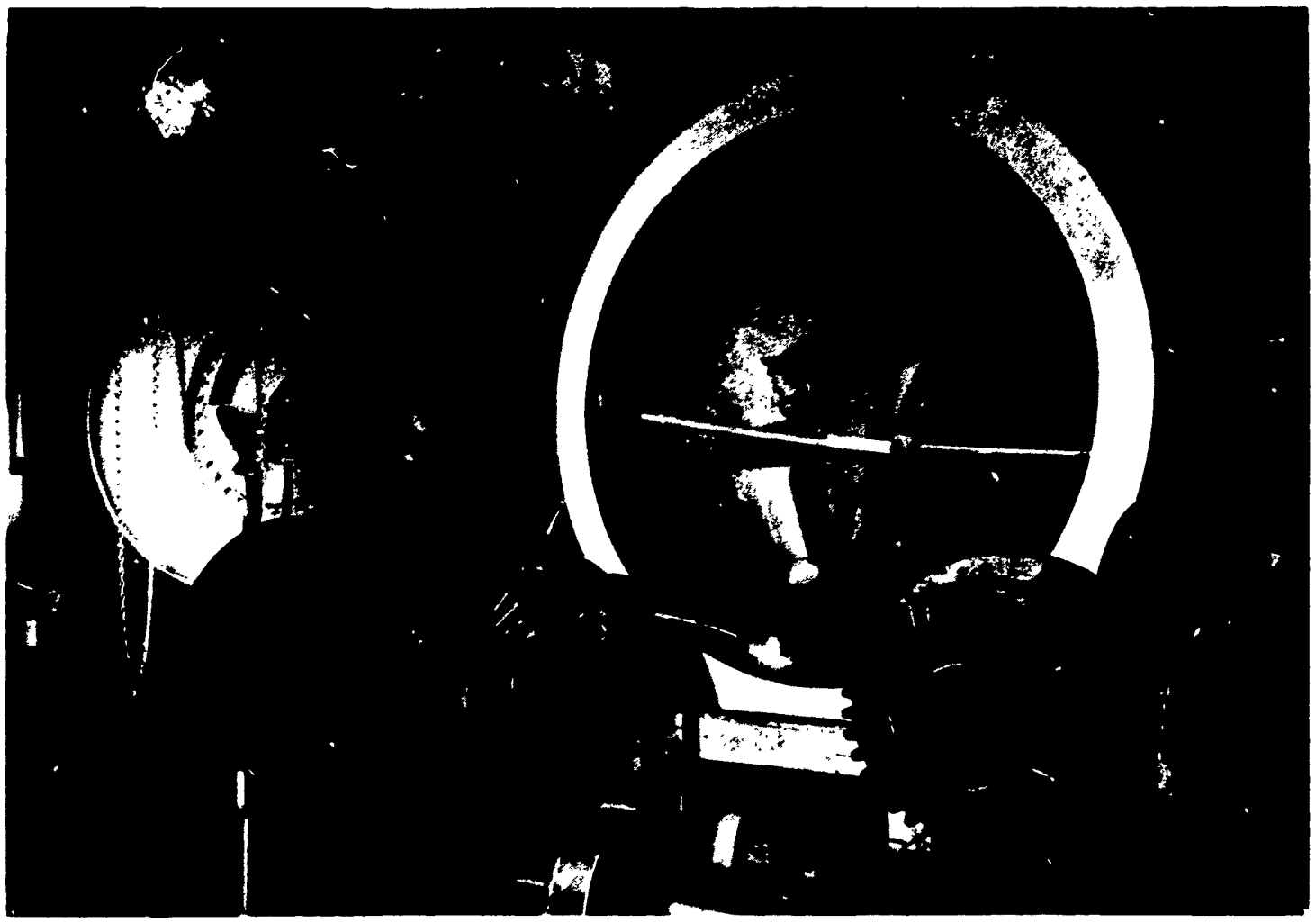
INFORMATION RELATIVE TO THE LESSON PLANS IN "INDUSTRIAL RADIOGRAPHY COURSE, INSTRUCTOR'S GUIDE, VOLUME I" (VT 003 565) IS PRESENTED ON 52 INFORMATION SHEETS INCLUDING THE SUBJECTS SHIELDING EQUATIONS AND LOGARITHMS, METAL PROPERTIES, FIELD TRIP INSTRUCTIONS FOR STUDENTS, WELDING SYMBOLS AND SIZES, SAMPLE REPORT FORMS, AND TYPICAL SHIPPING CONTAINER. THE SHEETS WERE PREPARED BY THE ENGINEERING EXTENSION SERVICE, TEXAS AGRICULTURAL AND MECHANICAL UNIVERSITY, COLLEGE STATION, TEXAS. THEY ARE FOR INSTRUCTOR USE AT THE POST-SECONDARY LEVEL WITH STUDENTS HAVING COURSES IN MATHEMATICS, CHEMISTRY, AND PHYSICS OR FORMAL TRAINING AS INDUSTRIAL OR MEDICAL X-RAY TECHNICIANS. THE SHEETS CAN BE DUPLICATED FOR CLASS DISTRIBUTION, OR THEY CAN BE PROJECTED. THEY ARE ILLUSTRATED WITH PHOTOGRAPHS, LINE DRAWINGS, AND TABLES. A BIBLIOGRAPHY OF BOOKS AND FILMS, AND A GLOSSARY ARE INCLUDED. (EM)

INSTRUCTORS' GUIDE Volume 2

INDUSTRIAL RADIOGRAPHY COURSE



U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education

INSTRUCTORS' GUIDE Volume 2

INDUSTRIAL RADIOGRAPHY COURSE

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

VT 003503

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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1967

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INFORMATION SHEETS

NOTE

The material contained in this volume consists of informational matter calculated to aid the instructor in his presentations.

In some instances, the instructor will find it advisable to duplicate some of the information sheets and use them as hand out material. In other situations it may be more advantageous to project the image on a screen using an overhead projector for this purpose.

Other applications may include the need for the disassembly of the text and its subsequent reassembly, all of which suggested the desireability of binding this material separately from the lesson plans and introductory statements.

Information Sheet
on
RADIOGRAPHER

Information
Sheet # 1

JOB DEFINITION

Controls radiography equipment to take radiographs of metal castings, weldments, metal samples, pipes, machinery, and structural members to detect flaws, cracks, porosity, and presence of foreign objects: Aligns object on stand between source of x-rays and film or plate; or aligns source of gamma rays, such as cobalt or iridium isotope and film or plate on opposite sides of object, manually or using hand or electric truck, chain hoist, or crane. Masks peripheral areas with lead shields. Selects type of radiation source and type of film, and applies standard mathematical formulas to determine exposure distance and time, considering size, mobility, and strength of radiation sources in relation to density and mobility of object. Verifies radiation intensities, using radiation meters. Takes radiograph by adjusting controls of x-ray machine or by exposing source of radioactivity. Removes and develops film or plate. Monitors working area, using survey meters, to protect personnel area. May replace radioactive isotope source in containers by manipulating tongs from behind protective lead shield. Marks defects appearing on film and assists in analyzing findings. May specialize in x-ray work and be designated as X-RAY TECHNICIAN.

EDUCATION, TRAINING, AND EXPERIENCE

High school graduation, including courses in mathematics, chemistry, and physics, is considered sufficient to qualify for on-the-job training. Formal training as an industrial or medical x-ray technician constitutes qualifying experience. Training or experience in welding, metallurgy or photography is considered helpful.

SPECIAL CHARACTERISTICS

Aptitudes:

Verbal ability to understand and discuss technical material related to construction, operation and application of equipment

Numerical ability to apply standard formulas when computing exposure time and distances to set up equipment

Spatial ability to determine optimum placement of objects and shielding preparatory to taking radiograph

Form perception to perceive pertinent details in exposed film

Temperaments:

Worker determines angle and distance of equipment to object and time and intensity of exposure on basis of verifiable criteria such as strength of radiation source and density of object. The attainment of precise standards of accuracy is involved.

Physical Demands and Working Conditions:

Work requires occasional lifting of materials weighing up to 20 pounds. In some establishments, worker occasionally may lift radiation containers weighing up to 75 pounds. Individual walks or stands most of the time

Climbing ladders sometimes is required to rig equipment or when photographing large objects such as aircraft

Stooping and crouching when working on materials at or below floor level

Reaching, handling and fingering required to work in a darkroom, set up equipment and adjust controls

The hazard of exposure to radiation is present although reduced by the presence of warning and safety devices. In some plants, may be exposed to noise levels of 80-90 decibels from welding machines and high frequency equipment

Work is performed indoors and outdoors.

* Job description from "Selected Occupations Concerned with Atomic Energy," June, 1961; BES No. E-197; Bureau of Employment Security, U.S. Dept. of Labor, Washington, D.C.

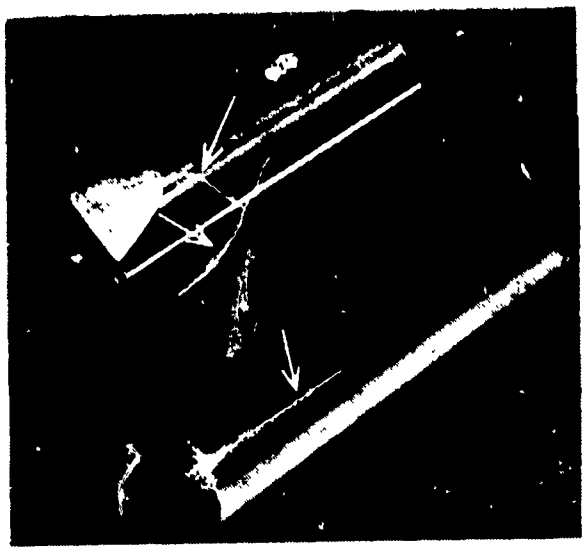
Information Sheet
on
SAMPLES OF NONDESTRUCTIVE
TESTING RESULTS

Information
Sheet # 2

1.

1. Cracks in critical jet engine blades as shown by Magnaglo paste method

2.



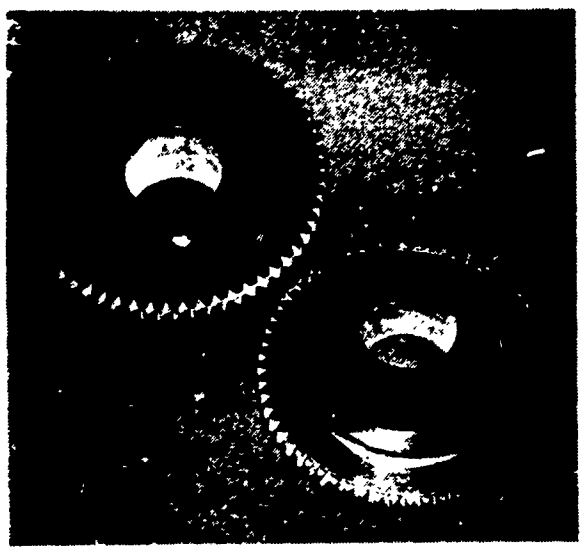
2. Heat treat cracks (a seam) as shown by the fluorescent magnetic particle method

3.

3. Welding defects as shown by the magnetic particle dry powder method

4. 

4. Quench cracks in steel castings as shown by the fluorescent magnetic particle method

5. 

5. Grinding check on gears as shown by the fluroescent magnetic particle method

6. 

6. Grinding cracks as shown by the fluorescent magnetic particle method

Information Sheet
on
ATOMIC ENERGY COMMISSION
REGULATIONS

PART 20

STANDARDS FOR PROTECTION AGAINST RADIATION

GENERAL PROVISIONS

§ 20.1 Purpose.

(a) The regulations in this part establish standards for protection against radiation hazards arising out of activities under licenses issued by the Atomic Energy Commission and are issued pursuant to the Atomic Energy Act of 1954 (68 Stat. 919).

(b) The use of radioactive material or other sources of radiation not licensed by the Commission is not subject to the regulations in this part. However, it is the purpose of the regulations in this part to control the possession, use, and transfer of licensed material by any licensee in such a manner that exposure to such material and to radiation from such material, when added to exposures to unlicensed radioactive material and to other unlicensed sources of radiation in the possession of the licensee, and to radiation therefrom, does not exceed the standards of radiation protection prescribed in the regulations in this part.

§ 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use or transfer byproduct material, source material, or special nuclear material under a general or specific license issued by the Commission pursuant to the regulations in Part 30, 40, or 70 of this chapter.

§ 20.3 Definitions.

(a) As used in this part:

(1) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

(2) "Airborne radioactive material" means any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases;

(3) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

(4) "Calendar quarter" means any period determined according to either of the following subdivisions:

(i) The first period of any year may begin on any date in January; provided that the second, third and fourth periods accordingly begin on the same date in April, July, and October, respectively, and that the fourth period extend into January of the succeeding year, if necessary to complete a three-month quarter. During the first year of use of this method of determination by a licensee, the first period for that year shall also include any additional days in January preceding the starting date for the first period.

(ii) The first period in a calendar year of 13 complete, consecutive calendar weeks; the second period in a calendar year of 13 complete, consecutive calendar weeks; the third period in a calendar year of 13 complete, consecutive calendar weeks; the fourth period in a calendar year of 13 complete, consecutive calendar weeks.

*Alternatively, the four periods may consist of the first 14 complete, consecutive calendar weeks; the next 12 complete, consecutive calendar weeks; the next 14 complete, consecutive calendar weeks; and the last 12 complete, consecutive calendar weeks. If at the end of a calendar year there are any days not falling within a complete calendar week of that year, such days shall be included (for purposes of this part) within the last complete calendar week of that year. If at the beginning of any calendar year there are days not falling within a complete calendar week of that year, such days shall be included (for purposes of this part) within the last complete calendar week of the previous year.

No licensee shall change the method observed by him of determining calendar quarters for purposes of this part except at the beginning of a calendar year.

(5) "Commission" means the Atomic Energy Commission or its duly authorized representatives;

(6) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

25 FR 10914

25 FR 13952

*Added 25 FR 13952

(7) "Individual" means any human being;

(8) "Licensed material" means source material, special nuclear material, or by-product material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter;

(9) "License" means a license issued under the regulations in Part 30, 40, or 70 of this chapter. "Licensee" means the holder of such license;

(10) "Occupational dose" includes exposure of an individual to radiation (i) in a restricted area; or (ii) in the course of employment in which the individual's duties involve exposure to radiation; provided, that "occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy of such individual.

(11) "Person" means (i) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission, any State, any foreign government or nation or any political subdivision of any such government or nations, or other entity; and (ii) any legal successor, representative, agent, or agency of the foregoing;

(12) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light;

(13) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission;

(14) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area;

(15) "Source material" means (i) uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of *a*. uranium, *b*. thorium or c. any combination thereof. Source material does not include special nuclear material.

(16) "Special nuclear material" means (i) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (ii) any material artificially enriched by any of the foregoing but does not include source material;

(17) "Unrestricted area" means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

(b) Definitions of certain other words and phrases as used in this part are set forth in other sections, including:

(1) "Airborne radioactivity area" defined in § 20.203;

(2) "Radiation area" and "high radiation area" defined in § 20.202;

(3) "Personnel monitoring equipment" defined in § 20.202;

(4) "Survey" defined in § 20.201;

(5) Units of measurement of dose (rad, rem) defined in § 20.4;

(6) Units of measurement of radioactivity defined in § 20.5.

§ 20.4 Units of radiation dose.

(a) "Dose," as used in this part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section.

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad) = 0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem) = 0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

(1) A dose of 1 *r* due to X- or gamma radiation;

(2) A dose of 1 rad due to X-, gamma, or beta radiation;

(3) A dose of 0.1 rad due to neutrons or high energy protons;

(4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye;

If it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in subparagraph (3) of this paragraph, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

NEUTRON FLUX DOSE EQUIVALENTS

Neutron energy (Mev)	Number of neutrons per square centimeter equivalent to a dose of 1 rem (neutrons/cm²)	Average flux to deliver 100 millirem in 40 hours (neutrons/cm² per sec.)
Thermal	970×10⁶	670
0.0001	720×10⁶	500
0.005	820×10⁶	570
0.02	400×10⁶	280
0.1	120×10⁶	80
0.5	43×10⁶	30
1.0	26×10⁶	18
2.5	29×10⁶	20
5.0	25×10⁶	18
7.5	24×10⁶	17
10	24×10⁶	17
10 to 30	14×10⁶	10

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in §§ 20.101 to 20.104, inclusive, may be assumed to be equivalent to the "air dose". For the purpose of this part "air dose" means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of highest dosage rate.

§ 20.5 Units of radioactivity.

(a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies. One curie (c) = 3.7×10^{10} disintegrations per second (dps) = 2.2×10^{12} disintegrations per minute (dpm). A commonly used submultiple of the curie is the microcurie (μc). One μc = 0.000001 c = 3.7×10^{4} dps = 2.2×10^{6} dpm.

(b) For purposes of the regulations in this part, it may be assumed that the daughter activity concentrations in the following table are equivalent to an air concentration of 10^{-7} microcuries of Radon 222 per milliliter of air in equilibrium with the daughters RaA, RaB, RaC, and RaC':

Maximum time between collection and measurement (hours)[1]	Alpha-emitting daughter activity collected per milliliter of air	
	Microcuries/cc	Total alpha disintegrations per minute per cc
0.5	7.2×10^{-8}	0.16
1	4.5×10^{-8}	0.10
2	1.3×10^{-8}	0.028
3	0.3×10^{-8}	0.0072

[1] The duration of sample collection and the duration of measurement should be sufficiently short compared to the time between collection and measurement, as not to have a statistically significant effect upon the results

(c) *Natural uranium and natural thorium.* (1) For purposes of the regulations in this part, one curie of natural uranium (U-natural in Appendix B or C) means the sum of 3.7×10^{10} disintegrations per second from U-238 plus 3.7×10^{10} dis/sec from U-234 plus 9×10^{8} dis/sec from U-235. Also, a curie of natural thorium (thorium-natural in Appendix B or C) means the sum of 3.7×10^{10} dis/sec from Th^{232} plus 3.7×10^{10} dis/sec from Th^{228}.

(2) For the purpose of the regulations in this part, one curie of natural uranium (U-natural in Appendix B or C) is equivalent to 3,000 kilograms, or 6,615 pounds of natural uranium; and one curie of natural thorium (thorium-natural in Appendix B or C) is equivalent to 9,000 kilograms or 19,850 pounds of natural thorium.

25 FR 10914

§ 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.7 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part, and applications filed under them, should be addressed to the Director of Regulation, U.S. Atomic Energy Commission, Washington, D.C., 20545. Communications, reports and applications may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C.; at 4915 St. Elmo Avenue, Bethesda, Md.; or at Germantown, Md.;

31 FR 4668

§ 20.101 Exposure of individuals to radiation in restricted areas.

(a) Except as provided in paragraph (b) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of the limits specified in the following table:

Rems per calendar quarter

1. Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1¼
2. Hands and forearms; feet and ankles	18¾
3. Skin of whole body	7½

25 FR 10914

(b) A licensee may permit an individual in a restricted area to receive a dose to the whole body greater than that permitted under paragraph (a) of this section, provided:

(1) During any calendar quarter the dose to the whole body from radioactive material and other sources of radiation in the licensee's possession shall not exceed 3 rems; and

(2) The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 (N-18) rems where 'N" equals the individual's age in years at his last birthday: and

(3) The licensee has determined the individual's accumulated occupational dose to the whole body on Form AEC-4, or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of § 20.102. As used in paragraph (b), "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

§ 20.102 Determination of accumulated dose.

(a) This section contains requirements which must be satisfied by licensees who propose, pursuant to paragraph (b) of § 20.101, to permit individuals in a restricted area to receive exposure to radiation in excess of the limits specified in paragraph (a) of § 20.101.

(b) Before permitting any individual in a restricted area to receive exposure to radiation in excess of the limits specified in paragraph (a) of § 20.101, each licensee shall:

(1) Obtain a certificate on Form AEC-4, or on a clear and legible record containing all the information required in that form, signed by the individual showing each period of time after the individual attained the age of 18 in which the individual received an occupational dose of radiation; and

(2) Calculate on Form AEC-4 in accordance with the instructions appearing therein, or on a clear and legible record containing all the information required in that form, the previously accumulated occupational dose received by the individual and the additional dose allowed for that individual under § 20.101(b).

(c)(1) In the preparation of Form AEC-4, or a clear and legible record containing all the information required in that form, the licensee shall make a reasonable effort to obtain reports of the individual's previously accumulated occupational dose. For each period for which the licensee obtains such reports, the licensee shall use the dose shown in the report in preparing the form. In any case where a licensee is unable to obtain reports of the individual's occupational dose for a previous complete calendar quarter, it shall be assumed that the individual has received the occupational dose specified in whichever of the following columns apply:

Part of body	Column 1 Assumed exposure in rems for calendar quarters prior to Jan. 1, 1961	Column 2 Assumed exposure in rems for calendar quarters beginning on or after Jan. 1, 1961
Whole body, gonads, active blood-forming organs, head and trunk, lens of eye.	3¾	1¼

(2) The licensee shall retain and preserve records used in preparing Form AEC-4.

If calculation of the individual's accumulated occupational dose for all periods prior to January 1, 1961 yields a result higher than the applicable accumulated dose value for the individual as of that date, as specified in paragraph (b) of § 20.101, the excess may be disregarded.

§ 20.103 Exposure of individuals to concentrations of radioactive material in restricted areas.

(a) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual in a restricted area to be exposed to airborne radioactive material possessed by the licensee in an average concentration in excess of the limits specified in Appendix B, Table I, of this part. "Expose" as used in this section means that the individual is present in an airborne concentration. No allowance shall be made for the use of protective clothing or equipment, or particle size, except as authorized by the Commission pursuant to paragraph (c) of this section.

(b) The limits given in Appendix B, Table I, of this part are based upon exposure to the concentrations specified for forty hours in any period of seven consecutive days. In any such period where the number of hours of exposure is less than forty, the limits specified in the table may be increased proportionately. In any such period where the number of hours of exposure is greater than forty, the limits specified in the table shall be decreased proportionately.

(c)(1) Except as authorized by the Commission pursuant to this paragraph, no allowance shall be made for particle size or the use of protective clothing or equipment in determining whether an individual is exposed to an airborne concentration in excess of the limits specified in Appendix B, Table I.

(2) The Commission may authorize a licensee to expose an individual in a restricted area to airborne concentrations in excess of the limits specified in Appendix B, Table I, upon receipt of an application demonstrating that the concentration is composed in whole or in part of particles of such size that such particles are not respirable; and that the individual will not inhale the concentrations in excess of the limits established in Appendix B, Table I. Each application under this subparagraph shall include an analysis of particle sizes in the concentrations; and a description of the methods used in determining the particle sizes.

(3) The Commission may authorize a licensee to expose an individual in a restricted area to airborne concentrations in excess of the limits specified in Appendix B, Table I, upon receipt of an application demonstrating that the individual will wear appropriate protective equipment and that the individual will not inhale, ingest or absorb quanti-

April 5, 1966

ties of radioactive material in excess of those which might otherwise be permitted under this part for employees in restricted areas during a 40-hour week. Each application under this subparagraph shall contain the following information:

(i) A description of the protective equipment to be employed, including the efficiency of the equipment for the material involved;

(ii) Procedures for the fitting, maintenance and cleaning of the protective equipment; and

(iii) Procedures governing the use of the protective equipment, including supervisory procedures and length of time the equipment will be used by the individuals in each work week. The proposed periods for use of the equipment by any individual should not be of such duration as would discourage observance by the individual of the proposed procedures; and

(iv) The average concentrations present in the areas occupied by employees.

§ 20.104 Exposure of minors.

(a) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area who is under 18 years of age, to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in the table in paragraph (a) of § 20.101.

(b) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area, who is under 18 years of age to be exposed to airborne radioactive material possessed by the licensee in an average concentration in excess of the limits specified in Appendix B, Table II of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than a week.

(c) The provisions of paragraph (c) of § 20.103, shall apply to exposures subject to paragraph (b) of this section.

§ 20.105 Permissible levels of radiation in unrestricted areas.

(a) There may be included in any application for a license or for amendment of a license proposed limits upon levels of radiation in unrestricted areas resulting from the applicant's possession or use of radioactive material and other sources of radiation. Such applications should include information as to anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that the proposed limits are not likely to cause any individual to receive a dose to the whole body in any period of one calendar year in excess of 0.5 rem.

(b) Except as authorized by the Commission pursuant to paragraph (a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

§ 20.106 Concentrations in effluents to unrestricted areas.

(a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix "B", Table II of this part, except as authorized pursuant to § 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

(b) An application for a license or amendment may include proposed limits higher than those specified in paragraph (a) of this section. The Commission will approve the proposed limits if the applicant demonstrates:

(1) That the applicant has made a reasonable effort to minimize the radioactivity contained in effluents to unrestricted areas; and

(2) That it is not likely that radioactive material discharged in the effluent would result in the exposure of an individual to concentrations of radioactive material in air or water exceeding the limits specified in Appendix "B", Table II of this part.

(c) An application for higher limits pursuant to paragraph (b) of this section shall include information demonstrating that the applicant has made a reasonable effort to minimize the radioactivity discharged in effluents to unrestricted areas, and shall include, as pertinent:

(1) Information as to flow rates, total volume of effluent, peak concentration of each radionuclide in the effluent, and concentration of each radionuclide in the effluent averaged over a period of one year at the point where the effluent leaves a stack, tube, pipe, or similar conduit;

(2) A description of the properties of the effluents, including:

(i) chemical composition;

(ii) physical characteristics, including suspended solids content in liquid effluents, and nature of gas or aerosol for air effluents;

(iii) the hydrogen ion concentrations (p^H) of liquid effluents; and

(iv) the size range of particulates in effluents released into air.

(3) A description of the anticipated human occupancy in the unrestricted area where the highest concentration of radioactive material from the effluent is expected, and, in the case of a river or stream, a description of water uses downstream from the point of release of the effluent.

(4) Information as to the highest concentration of each radionuclide in an unrestricted area, including anticipated concentrations averaged over a period of one year:

(i) In air at any point of human occupancy; or

(ii) In water at points of use downstream from the point of release of the effluent.

(5) The background concentration of radionuclides in the receiving river or stream prior to the release of liquid effluent.

(6) A description of the environmental monitoring equipment, including sensitivity of the system, and procedures and calculations to determine concentrations of radionuclides in the unrestricted area and possible reconcentrations of radionuclides.

(7) A description of the waste treatment facilities and procedures used to reduce the concentration of radionuclides in effluents prior to their release.

(d) For the purposes of this section the concentration limits in Appendix "B", Table II of this part shall apply at the boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution, dispersion, or decay between the point of discharge and the boundary.

(e) In addition to limiting concentrations in effluent streams, the Commission may limit quantities of radioactive materials released in air or water during a specified period of time if it appears that the daily intake of radioactive material from air, water, or food by a suitable sample of an exposed population group, averaged over a period not exceeding one year, would otherwise exceed the daily intake resulting from continuous exposure to air or water containing one-third the concentration of radioactive materials specified in Appendix "B", Table II of this part.

(f) The provisions of this section do not apply to disposal of radioactive material into sanitary sewerage systems, which is governed by § 20.303

§ 20.107 Medical diagnosis and therapy.

Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

§ 20.108 Orders requiring furnishing of bio-assay services.

Where necessary or desirable in order to aid in determining the extent of an individual's exposure to concentrations of radioactive material, the Commission may incorporate appropriate provisions in any license, directing the licensee to make available to the individual appropriate bio-assay services and to furnish a copy of the reports of such services to the Commission.

PRECAUTIONARY PROCEDURES

§ 20.201 Surveys.

(a) As used in the regulations in this part, "survey" means an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive material present.

(b) Each licensee shall make or cause to be made such surveys as may be necessary for him to comply with the regulations in this part.

§ 20.202 Personnel monitoring.

(a) Each licensee shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by:

(1) Each individual who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable value specified in paragraph (a) of § 20.101.

(2) Each individual under 18 years of age who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent of the applicable value specified in paragraph (a) of § 20.101.

(3) Each individual who enters a high radiation area.

(b) As used in this part,

(1) "Personnel monitoring equipment" means devices designed to be worn or carried by an individual for the purpose of measuring the dose received (e. g., film badges, pocket chambers, pocket dosimeters, film rings, etc.);

(2) "Radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirems;

(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

[25 FR 10914]

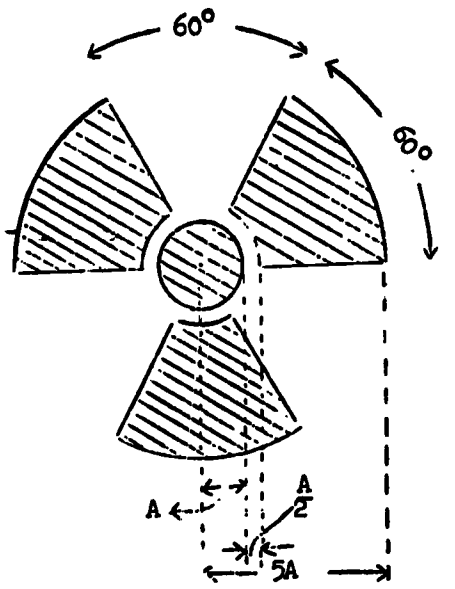
[1] Or "Danger".

§ 20.203 Caution signs, labels, and signals.

(a) *General.* (1) Except as otherwise authorized by the Commission, symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this section is the conventional three-bladed design:

RADIATION SYMBOL

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.



(2) In addition to the contents of signs and labels prescribed in this section, licensees may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation or to radioactive material.

(b) *Radiation areas.* Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION[1]
RADIATION AREA

(c) *High radiation areas.* (1) Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION[1]
HIGH RADIATION AREA

(2) Each high radiation area shall be equipped with a control device which shall either cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirem in one hour upon entry into the area or shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering and the licensee or a supervisor of the activity are made aware of the entry. In the case of a high radiation area established for a period of 30 days or less, such control device is not required.

(d) *Airborne radioactivity areas.* (1) As used in the regulations in this part, "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix B, Table I, Column 1 of this part; or (ii) any room, enclosure, or operating area in which airborne radioactive material composed wholly or partly of licensed material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in Appendix B, Table I, Column 1 of this part.

(2) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION[1]
AIRBORNE RADIOACTIVITY AREA

(e) *Additional requirements.* (1) Each area or room in which licensed material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in an amount exceeding 10 times the quantity of such material specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION[1]
RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in an amount exceeding one-hundred times the quantity specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Except as provided in subparagraph (3) of this paragraph, each container of licensed material shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to subparagraph (1) of this paragraph shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information[1] to permit individuals handling or using the containers, or working in the vicinity thereof, to take precautions to avoid or minimize exposures.

(3) Notwithstanding the provisions of subparagraph (1) of this paragraph, labeling is not required:

(i) For containers that do not contain licensed materials in quantities greater than the applicable quantities listed in Appendix C of this part.

(ii) For containers containing only natural uranium or thorium in quantities no greater than 10 times the applicable quantities listed in Appendix C of this part.

(iii) For containers that do not contain licensed materials in concentrations

[31 FR 10514]

[1] As appropriate, the information will include radiation levels, kinds of material, estimate of activity, date for which activity is estimated, mass enrichment, etc.

greater than the applicable concentrations listed in Column 2, Table I, Appendix B of this part.

(iv) For containers when they are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established by the regulations in this part.

(v) For containers when they are in transport and packaged and labeled in accordance with regulations of the Interstate Commerce Commission, Federal Aviation Agency, or Coast Guard.

(vi) For containers which are accessible[2] only to individuals authorized to handle or use them, or to work in the vicinity thereof, provided that the contents are identified to such individuals by a readily available written record.

(vii) For manufacturing or process equipment, such as nuclear reactors, reactor components, piping, and tanks.

31 FR 10514

§ 20.204 Exceptions from posting requirements.

Notwithstanding the provisions of § 20.203.

(a) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level twelve inches from the surface of the source container or housing does not exceed five millirem per hour.

(b) Rooms or other areas in hospitals are not required to be posted with caution signs because of the presence of patients containing byproduct material provided that there are personnel in attendance who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the regulations in this part.

25 FR 10914

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours provided that (1) the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations in this part and: (2) such area or room is subject to the licensee's control.

31 FR 10514

(d) A room or other area is not required to be posted with a caution sign because of the presence of radioactive materials packaged and labeled in accordance with regulations of the Interstate Commerce Commission, Federal Aviation Agency, or Coast Guard.

25 FR 10914

§ 20.206 Instruction of personnel: posting of notices to employees.

(a) All individuals working in or frequenting any portion of a restricted area shall be informed of the occurrence of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the safety problems associated with exposure to such materials or radiation and in precautions or procedures to minimize exposure; shall be instructed in the applicable provisions of Commission regulations and licenses for the protection of personnel from exposures to radiation or radioactive materials; and shall be advised of reports of radiation exposure which employees may request pursuant to these regulations.

(b) Each licensee shall post a current copy of the regulations in this part, a copy of the license, and a copy of operating procedures applicable to work under the license conspicuously in a sufficient number of places in every establishment where employees are employed in activities licensed by the Commission to permit them to observe such documents on the way to or from their place of employment or shall keep such documents available for employees' examination upon request.

25 FR 13952

(c) Form AEC-3, "Notice to Employees", shall be conspicuously posted in a sufficient number of places in every establishment where employees are employed in activities licensed by the Commission to permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.

31 FR 4668

NOTE: Copies of Form AEC-3, "Notice to Employees," may be obtained by writing to the Director of the appropriate U.S. Atomic Energy Commission Regional Compliance Office listed in Appendix "D" or the Director, Division of Materials Licensing, U.S. Atomic Energy Commission, Washington, D.C., 20545.

§ 20.207 Storage of licensed materials.

Licensed materials stored in an unrestricted area shall be secured against unauthorized removal from the place of storage.

WASTE DISPOSAL

§ 20.301 General requirement.

No licensee shall dispose of licensed material except:

(a) By transfer to an authorized recipient as provided in the regulations in Part 30, 40, or 70 of this chapter, whichever may be applicable; or

(b) As authorized pursuant to § 20.302; or

25 FR 10914

(c) As provided in § 20.303 or § 20.304, applicable respectively to the disposal of licensed material by release into sanitary sewerage systems or burial in soil, or in § 20.106 (Concentrations in Effluents to Unrestricted Areas).

§ 20.302 Method for obtaining approval of proposed disposal procedures.

Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

26 FR 352

The Commission will not approve any application for a license to receive licensed material from other persons for disposal on land not owned by the Federal government or by a State government.

§ 20.303 Disposal by release into sanitary sewerage systems.

No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of subparagraphs (1) or (2) of this paragraph:

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix B, Table I, Column 2 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix B, Table I, Column 2 of this part; and

25 FR 10914

(d) The gross quantity of licensed and other radioactive material released into the sewerage system by the licensee does not exceed one curie per year.

Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

§ 20.304 Disposal by burial in soil.

No licensee shall dispose of licensed material by burial in soil unless:

(a) The total quantity of licensed and other radioactive materials buried at any one location and time does not exceed, at the time of burial, 1,000 times the amount specified in Appendix C of this part; and

(b) Burial is at a minimum depth of four feet; and

(c) Successive burials are separated by distances of at least six feet and not more than 12 burials are made in any year.

[2] For example, containers in locations such as water-filled canals, storage vaults, or hot cells.

PART 20 - STANDARDS FOR PROTECTION AGAINST RADIATION

§ 20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration except as specifically approved by the Commission pursuant to §§ 20.106(b) and 20.302.

RECORDS, REPORTS, AND NOTIFICATION

§ 20.401 Records of surveys, radiation monitoring, and disposal.

(a) Each licensee shall maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required under § 20.202 of the regulations in this part. Such records shall be kept on Form AEC-5, in accordance with the instructions contained in that form or on clear and legible records containing all the information required by Form AEC-5 The doses entered on the forms or records shall be for periods of time not exceeding one calendar quarter.

(b) Each licensee shall maintain records in the same units used in the appendices to this part, showing the results of surveys required by § 20.201 (b), and disposals made under §§ 20.302, 20.303, and 20.304.

25 FR 10914

(c) Records of individual radiation exposure which must be maintained pursuant to the provisions of paragraph (a) of this section shall be preserved until December 31, 1970, or until a date 5 years after termination of the individual's employment, whichever is later. Records which must be maintained pursuant to this part may be maintained in the form of microfilms.

30 FR 14551

NOTE: Prior to December 31, 1970, the Commission may amend this paragraph to assure the further preservation of records which it determines should not be destroyed.

§ 20.402 Reports of theft or loss of licensed material.

Each licensee shall report by telephone and telegraph to the Director of the appropriate Atomic Energy Commission Regional Compliance Office listed in Appendix D, immediately after its occurrence becomes known to the licensee, any loss or theft of licensed material in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

27 FR 5905

§ 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately notify the Director of the appropriate Atomic Energy Commission Regional Compliance Office shown in Appendix D by telephone and telegraph of any incident involving byproduct, source or special nuclear material possessed by him and which may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more of radiation; or exposure of the feet, ankles, hands or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II; or

(3) A loss of one working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of $100,000.

(b) *Twenty-four hour notification* Each licensee shall within 24 hours notify the Director of the appropriate Atomic Energy Commission Regional Compliance Office listed in Appendix D by telephone and telegraph of any incident involving licensed material possessed by him and which may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II; or

(3) A loss of one day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $1,000.

28 FR 6822

(c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

§ 20.404 Report to former employees of exposure to radiation.

At the request of a former employee each licensee shall furnish to the former employee a report of the former employee's exposure to radiation as shown in records maintained by the licensee pursuant to § 20.401(a). Such report shall be furnished within 30 days from the time the request is made; shall cover each calendar quarter of the individual's employment involving exposure to radiation, or such lesser period as may be requested by the employee. The report shall also include the results of any calculations and analyses of radioactive material deposited in the body of the employee and made pursuant to the provisions of § 20.108. The report shall be in writing and contain the following statement:

25 FR 10914

This report is furnished to you under the provisions of the Atomic Energy Commission regulations entitled "Standards for Protection Against Radiation" (10 CFR Part 20). You should preserve this report for future reference

(b) The former employee's request should include appropriate identifying data, such as social security number and dates and locations of employment.

27 FR 5905

§ 20.405 Reports of overexposures and excessive levels and concentrations.

(a) In addition to any notification required by § 20.403, each licensee shall make a report in writing within 30 days to the • Director, Division of State and Licensee Relations, U.S. Atomic Energy Commission, Washington, D.C., 20545 , with a copy to the Director of the appropriate Atomic Energy Commission Regional Compliance Office listed in Appendix D, of (1) each exposure of an individual to radiation or concentrations of radioactive material in excess of any applicable limit in this part or in the licensee's license; (2) any incident for which notification is required by § 20.403; and (3) levels of radiation or concentrations of radioactive material (not involving excessive exposure of any individual) in an unrestricted area in excess of ten times any applicable limit set forth in this part or in the licensee's license. Each report required under this paragraph shall describe the extent of exposure of persons to radiation or to radioactive material; levels of radiation and concentrations of radioactive material involved; the cause of the exposure, levels or concentrations; and corrective steps taken or planned to assure against a recurrence.

25 FR 10914

(b) In any case where a licensee is required pursuant to the provisions of this section to report to the Commission any exposure of an individual to radiation or to concentrations of radioactive material, the licensee shall also notify such individual of the nature and extent of exposure. Such notice shall be in writing and shall contain the following statement:

This report is furnished to you under the provisions of the Atomic Energy Commission regulations entitled "Standards for Protection Against Radiation" (10 CFR Part 20) You should preserve this report for future reference

28 FR 6822

(c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

§ 20.406 Notice to employees of exposure to radiation.

At the request of any employee each licensee shall advise such employee annually of the employee's exposure to radiation as shown in records maintained by the licensee pursuant to § 20.401(a).

25 FR 10914

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

§ 20.501 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 20.502 Additional requirements.

The Commission may, by rule, regulation, or order, impose upon any licensee such requirements, in addition to those

*Revised 31 FR 4668

April 5, 1966

established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

ENFORCEMENT

§ 20.60 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the act or any regulation or order issued thereunder. Any person who willfully violates any provision of the act or any regulation or order issued thereunder may be guilty of a crime, and upon conviction, may be punished by fine or imprisonment or both, as provided by law.

[25 FR 10914]

APPENDIX A [Reserved]

APPENDIX B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-9}	8×10^{-14}	2×10^{-9}
		I	8×10^{-11}	9×10^{-9}	9×10^{-12}	3×10^{-9}
	Ac 228	S	6×10^{-9}	3×10^{-8}	3×10^{-9}	9×10^{-9}
		I	2×10^{-8}	3×10^{-8}	6×10^{-10}	9×10^{-9}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	1×10^{-10}	6×10^{-9}	4×10^{-12}	2×10^{-9}
	Am 242m	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	3×10^{-10}	3×10^{-9}	9×10^{-13}	9×10^{-9}
*	Am 242	S	4×10^{-8}	4×10^{-8}	1×10^{-9}	1×10^{-8}
		I	9×10^{-8}	4×10^{-8}	2×10^{-9}	1×10^{-8}
	Am 243	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	1×10^{-10}	5×10^{-9}	4×10^{-12}	3×10^{-9}
*	Am 244	S	4×10^{-8}	1×10^{-7}	1×10^{-7}	5×10^{-8}
		I	2×10^{-8}	1×10^{-7}	8×10^{-9}	5×10^{-8}
Antimony (51)	Sb 122	S	2×10^{-7}	8×10^{-8}	6×10^{-8}	3×10^{-8}
		I	1×10^{-7}	6×10^{-8}	5×10^{-8}	3×10^{-8}
	Sb 124	S	2×10^{-7}	7×10^{-8}	5×10^{-8}	2×10^{-8}
		I	2×10^{-8}	7×10^{-8}	7×10^{-10}	2×10^{-8}
	Sb 125	S	5×10^{-7}	3×10^{-8}	2×10^{-8}	1×10^{-8}
		I	3×10^{-8}	3×10^{-8}	9×10^{-10}	1×10^{-8}
Argon (18)	A 37	Sub[2]	6×10^{-5}	----------	1×10^{-6}	----------
	A 41	Sub	2×10^{-8}	----------	4×10^{-9}	----------
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}
		I	4×10^{-7}	1×10^{-8}	1×10^{-8}	5×10^{-8}
	As 74	S	3×10^{-7}	2×10^{-8}	1×10^{-8}	5×10^{-8}
		I	1×10^{-7}	2×10^{-8}	4×10^{-9}	5×10^{-8}
	As 76	S	1×10^{-7}	6×10^{-8}	4×10^{-9}	2×10^{-8}
		I	1×10^{-7}	6×10^{-8}	3×10^{-9}	2×10^{-8}
	As 77	S	5×10^{-7}	2×10^{-8}	2×10^{-9}	8×10^{-8}
		I	4×10^{-7}	2×10^{-8}	1×10^{-9}	8×10^{-8}
Astatine (85)	At 211	S	7×10^{-9}	8×10^{-8}	2×10^{-10}	2×10^{-8}
		I	3×10^{-8}	2×10^{-7}	1×10^{-9}	7×10^{-8}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-7}	4×10^{-8}	2×10^{-8}
		I	4×10^{-7}	5×10^{-7}	1×10^{-8}	2×10^{-8}
	Ba 140	S	1×10^{-7}	8×10^{-8}	4×10^{-9}	3×10^{-8}
		I	4×10^{-8}	7×10^{-8}	1×10^{-9}	2×10^{-8}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-7}	3×10^{-11}	6×10^{-8}
		I	1×10^{-7}	2×10^{-7}	4×10^{-9}	6×10^{-8}
*	Bk 250	S	1×10^{-7}	6×10^{-8}	5×10^{-9}	2×10^{-8}
		I	1×10^{-8}	6×10^{-8}	4×10^{-9}	2×10^{-8}
Beryllium (4)	Be 7	S	6×10^{-6}	5×10^{-5}	2×10^{-7}	2×10^{-8}
		I	1×10^{-6}	5×10^{-5}	4×10^{-8}	2×10^{-8}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-8}	6×10^{-9}	4×10^{-8}
		I	1×10^{-7}	1×10^{-7}	5×10^{-9}	4×10^{-8}
	Bi 207	S	2×10^{-7}	2×10^{-8}	6×10^{-9}	6×10^{-8}
		I	1×10^{-8}	2×10^{-8}	5×10^{-10}	6×10^{-8}
	Bi 210	S	6×10^{-9}	1×10^{-8}	2×10^{-10}	4×10^{-8}
		I	6×10^{-9}	1×10^{-8}	2×10^{-10}	4×10^{-8}
	Bi 212	S	1×10^{-7}	1×10^{-8}	3×10^{-9}	4×10^{-8}
		I	2×10^{-7}	1×10^{-8}	7×10^{-9}	4×10^{-8}
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-8}	4×10^{-8}	3×10^{-8}
		I	2×10^{-7}	1×10^{-8}	6×10^{-9}	4×10^{-8}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-8}	2×10^{-9}	2×10^{-8}
		I	7×10^{-8}	5×10^{-8}	3×10^{-9}	2×10^{-8}
	Cd 115m	S	4×10^{-8}	7×10^{-8}	1×10^{-9}	3×10^{-8}
		I	4×10^{-7}	7×10^{-8}	1×10^{-9}	3×10^{-8}
	Cd 115	S	2×10^{-7}	1×10^{-8}	8×10^{-9}	2×10^{-8}
		I	2×10^{-7}	1×10^{-8}	6×10^{-9}	4×10^{-8}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-8}	1×10^{-9}	9×10^{-9}
		I	1×10^{-7}	5×10^{-8}	4×10^{-9}	2×10^{-8}
	Ca 47	S	2×10^{-7}	1×10^{-8}	6×10^{-9}	5×10^{-8}
		I	2×10^{-7}	1×10^{-8}	6×10^{-9}	8×10^{-8}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-8}	5×10^{-14}	4×10^{-8}
		I	1×10^{-10}	7×10^{-8}	3×10^{-12}	2×10^{-7}
	Cf 250	S	5×10^{-12}	4×10^{-8}	2×10^{-13}	1×10^{-7}
		I	1×10^{-10}	7×10^{-8}	3×10^{-12}	3×10^{-7}
*	Cf 251	S	2×10^{-15}	1×10^{-8}	9×10^{-16}	4×10^{-8}
		I	1×10^{-10}	8×10^{-8}	3×10^{-12}	3×10^{-7}
	Cf 252	S	2×10^{-11}	7×10^{-8}	7×10^{-13}	2×10^{-7}
		I	1×10^{-10}	7×10^{-8}	4×10^{-12}	2×10^{-7}

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Californium (98)	Cf 253	S	8×10^{-10}	4×10^{-8}	3×10^{-11}	1×10^{-7}
		I	6×10^{-10}	4×10^{-8}	2×10^{-11}	1×10^{-7}
*	Cf 254	S	8×10^{-13}	4×10^{-8}	2×10^{-14}	1×10^{-7}
		I	8×10^{-10}	4×10^{-8}	2×10^{-14}	1×10^{-7}
Carbon (6)	C 14	S	4×10^{-6}	2×10^{-5}	1×10^{-7}	8×10^{-8}
	(CO_2)	Sub	5×10^{-5}	----------	1×10^{-6}	----------
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-7}	2×10^{-8}	9×10^{-8}
		I	2×10^{-7}	3×10^{-7}	5×10^{-9}	9×10^{-8}
	Ce 143	S	3×10^{-7}	1×10^{-7}	9×10^{-9}	4×10^{-8}
		I	2×10^{-7}	1×10^{-7}	7×10^{-9}	4×10^{-8}
	Ce 144	S	1×10^{-8}	3×10^{-8}	3×10^{-10}	1×10^{-8}
		I	6×10^{-9}	3×10^{-8}	2×10^{-10}	1×10^{-8}
Cesium (55)	Cs 131	S	1×10^{-6}	7×10^{-6}	4×10^{-7}	2×10^{-6}
		I	3×10^{-6}	3×10^{-6}	1×10^{-7}	9×10^{-7}
	Cs 134m	S	4×10^{-6}	2×10^{-6}	1×10^{-6}	6×10^{-7}
		I	6×10^{-6}	2×10^{-6}	2×10^{-7}	1×10^{-7}
	Cs 134	S	4×10^{-8}	3×10^{-8}	1×10^{-9}	9×10^{-9}
		I	1×10^{-8}	1×10^{-8}	4×10^{-10}	4×10^{-9}
	Cs 135	S	5×10^{-7}	3×10^{-8}	2×10^{-9}	1×10^{-8}
		I	9×10^{-8}	7×10^{-8}	3×10^{-9}	2×10^{-8}
	Cs 136	S	4×10^{-7}	2×10^{-8}	1×10^{-8}	9×10^{-8}
		I	2×10^{-7}	2×10^{-8}	6×10^{-9}	6×10^{-8}
	Cs 137	S	6×10^{-8}	4×10^{-8}	2×10^{-9}	2×10^{-8}
		I	1×10^{-8}	1×10^{-8}	5×10^{-10}	4×10^{-9}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-8}	1×10^{-8}	8×10^{-8}
		I	2×10^{-6}	2×10^{-8}	8×10^{-10}	6×10^{-9}
	Cl 38	S	3×10^{-6}	1×10^{-7}	9×10^{-8}	4×10^{-7}
		I	2×10^{-6}	1×10^{-7}	7×10^{-8}	4×10^{-7}
Chromium (24)	Cr 51	S	1×10^{-6}	5×10^{-6}	4×10^{-7}	2×10^{-6}
		I	2×10^{-6}	5×10^{-6}	8×10^{-8}	2×10^{-6}
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-6}	1×10^{-7}	8×10^{-7}
		I	2×10^{-7}	1×10^{-6}	6×10^{-8}	4×10^{-7}
	Co 58m	S	2×10^{-6}	8×10^{-6}	6×10^{-7}	2×10^{-6}
		I	9×10^{-6}	6×10^{-6}	3×10^{-7}	2×10^{-6}
	Co 58	S	8×10^{-7}	4×10^{-6}	3×10^{-8}	1×10^{-6}
		I	5×10^{-6}	3×10^{-6}	2×10^{-8}	9×10^{-7}
	Co 60	S	3×10^{-7}	1×10^{-6}	1×10^{-8}	5×10^{-7}
		I	9×10^{-6}	1×10^{-6}	3×10^{-10}	2×10^{-6}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-6}	7×10^{-8}	2×10^{-6}
		I	1×10^{-6}	6×10^{-6}	4×10^{-8}	2×10^{-6}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-8}	4×10^{-12}	2×10^{-7}
		I	2×10^{-10}	7×10^{-8}	6×10^{-12}	2×10^{-7}
	Cm 243	S	6×10^{-11}	1×10^{-7}	2×10^{-12}	5×10^{-7}
		I	1×10^{-10}	7×10^{-7}	3×10^{-12}	2×10^{-7}
	Cm 244m	S	9×10^{-12}	2×10^{-7}	3×10^{-13}	7×10^{-7}
		I	1×10^{-10}	8×10^{-7}	3×10^{-12}	8×10^{-7}
	Cm 245	S	5×10^{-12}	1×10^{-7}	2×10^{-13}	4×10^{-7}
		I	1×10^{-9}	8×10^{-7}	4×10^{-12}	3×10^{-7}
	Cm 246	S	5×10^{-12}	1×10^{-7}	2×10^{-13}	4×10^{-7}
		I	1×10^{-10}	8×10^{-7}	4×10^{-12}	3×10^{-7}
	Cm 247	S	5×10^{-13}	1×10^{-7}	2×10^{-13}	4×10^{-7}
		I	1×10^{-10}	6×10^{-7}	4×10^{-12}	2×10^{-7}
*	Cm 248	S	6×10^{-13}	1×10^{-7}	2×10^{-14}	4×10^{-7}
		I	1×10^{-11}	4×10^{-7}	4×10^{-13}	1×10^{-6}
	Cm 249	S	1×10^{-6}	6×10^{-7}	4×10^{-7}	2×10^{-6}
		I	1×10^{-6}	6×10^{-7}	4×10^{-7}	2×10^{-6}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-6}	9×10^{-8}	4×10^{-7}
		I	2×10^{-6}	1×10^{-6}	7×10^{-8}	4×10^{-7}
	Dy 166	S	2×10^{-7}	1×10^{-6}	8×10^{-9}	4×10^{-7}
		I	2×10^{-7}	1×10^{-6}	7×10^{-9}	4×10^{-7}
*						
Einsteinium (99)	Es 253	S	8×10^{-10}	[illegible]	3×10^{-11}	2×10^{-7}
		I	6×10^{-10}	[illegible]	2×10^{-11}	2×10^{-7}
	Es 254m	S	5×10^{-9}	[illegible]	2×10^{-10}	2×10^{-7}
		I	6×10^{-9}	[illegible]	2×10^{-10}	2×10^{-7}
	Es 254	S	2×10^{-11}	[illegible]	8×10^{-13}	1×10^{-7}
		I	1×10^{-10}	[illegible]	4×10^{-12}	1×10^{-7}
	Es 255	S	5×10^{-10}	[illegible]	2×10^{-11}	3×10^{-7}
		I	4×10^{-10}	[illegible]	1×10^{-11}	3×10^{-7}
Erbium (68)	Er 169	S	6×10^{-7}	8×10^{-8}	2×10^{-8}	9×10^{-7}
		I	4×10^{-7}	8×10^{-8}	1×10^{-8}	9×10^{-7}
	Er 171	S	7×10^{-7}	2×10^{-7}	2×10^{-8}	1×10^{-6}
		I	6×10^{-7}	3×10^{-7}	2×10^{-8}	1×10^{-6}

See footnotes at end of table.

*Added 30 FR 15801

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Europium (63)	Eu 152 (T/2=9.2 hrs)	S	4×10⁻⁷	2×10⁻³	1×10⁻⁶	8×10⁻⁶
		I	3×10⁻⁷	2×10⁻³	1×10⁻⁶	8×10⁻⁶
	Eu 152 (T/2=13 yrs)	S	1×10⁻⁸	2×10⁻⁸	4×10⁻¹⁰	8×10⁻⁸
		I	2×10⁻⁸	2×10⁻⁸	6×10⁻¹⁰	8×10⁻⁸
	Eu 154	S	4×10⁻⁸	6×10⁻⁸	1×10⁻¹⁰	2×10⁻⁷
		I	7×10⁻⁸	6×10⁻⁸	2×10⁻¹⁰	2×10⁻⁷
	Eu 155	S	9×10⁻⁸	6×10⁻⁸	3×10⁻⁹	2×10⁻⁷
		I	7×10⁻⁸	6×10⁻⁸	3×10⁻⁹	2×10⁻⁷
Fermium (100)	Fm 254	S	8×10⁻⁶	4×10⁻⁶	2×10⁻⁸	1×10⁻⁶
		I	7×10⁻⁶	4×10⁻⁶	2×10⁻⁸	1×10⁻⁶
	Fm 255	S	2×10⁻⁶	1×10⁻⁶	6×10⁻¹⁰	2×10⁻⁶
		I	1×10⁻⁶	1×10⁻⁶	4×10⁻¹⁰	2×10⁻⁶
	Fm 256	S	3×10⁻⁶	3×10⁻⁶	1×10⁻¹⁰	9×10⁻⁷
		I	2×10⁻⁶	3×10⁻⁶	6×10⁻¹¹	9×10⁻⁷
Fluorine (9)	F 18	S	5×10⁻⁶	2×10⁻³	2×10⁻⁷	8×10⁻⁶
		I	3×10⁻⁶	1×10⁻³	9×10⁻⁸	5×10⁻⁶
Gadolinium (64)	Gd 153	S	2×10⁻⁷	6×10⁻⁸	8×10⁻⁸	2×10⁻⁶
		I	9×10⁻⁹	6×10⁻⁸	3×10⁻⁸	2×10⁻⁶
	Gd 159	S	5×10⁻⁷	2×10⁻⁸	2×10⁻⁸	8×10⁻⁶
		I	4×10⁻⁷	2×10⁻⁸	1×10⁻⁸	8×10⁻⁶
Gallium (31)	Ga 72	S	2×10⁻⁷	1×10⁻³	8×10⁻⁸	4×10⁻³
		I	2×10⁻⁷	1×10⁻³	8×10⁻⁸	4×10⁻³
Germanium (32)	Ge 71	S	1×10⁻⁵	5×10⁻³	4×10⁻⁷	2×10⁻³
		I	6×10⁻⁶	5×10⁻³	2×10⁻⁷	2×10⁻³
Gold (79)	Au 196	S	1×10⁻⁶	5×10⁻³	4×10⁻⁸	2×10⁻⁶
		I	8×10⁻⁷	4×10⁻³	2×10⁻⁸	1×10⁻⁶
	Au 198	S	3×10⁻⁷	2×10⁻³	1×10⁻⁸	5×10⁻⁶
		I	2×10⁻⁷	1×10⁻³	8×10⁻⁹	5×10⁻⁶
	Au 199	S	1×10⁻⁶	5×10⁻³	4×10⁻⁸	2×10⁻⁶
		I	8×10⁻⁷	4×10⁻³	3×10⁻⁸	2×10⁻⁶
Hafnium (72)	Hf 181	S	4×10⁻⁸	2×10⁻³	1×10⁻⁸	7×10⁻⁶
		I	7×10⁻⁸	2×10⁻³	3×10⁻⁸	7×10⁻⁶
Holmium (67)	Ho 166	S	2×10⁻⁷	9×10⁻⁴	7×10⁻⁸	3×10⁻³
		I	2×10⁻⁷	9×10⁻⁴	6×10⁻⁸	3×10⁻³
Hydrogen (1)	H3	S	8×10⁻⁴	1×10⁻¹	2×10⁻⁷	3×10⁻³
	**	I	8×10⁻⁴	1×10⁻¹	2×10⁻⁷	3×10⁻³
		Sub	2×10⁻³	----------	4×10⁻⁶	----------
Indium (49)	In 113m	S	8×10⁻⁶	4×10⁻³	3×10⁻⁷	1×10⁻³
		I	7×10⁻⁶	4×10⁻³	2×10⁻⁷	1×10⁻³
	In 114m	S	1×10⁻⁷	5×10⁻⁴	4×10⁻⁹	2×10⁻⁴
		I	2×10⁻⁸	5×10⁻⁴	7×10⁻¹⁰	2×10⁻⁴
	In 115m	S	2×10⁻⁶	1×10⁻³	6×10⁻⁸	4×10⁻⁴
		I	2×10⁻⁶	1×10⁻³	6×10⁻⁸	4×10⁻⁴
	In 115	S	2×10⁻⁷	3×10⁻³	9×10⁻⁹	9×10⁻⁴
		I	3×10⁻⁸	3×10⁻³	1×10⁻⁸	9×10⁻⁴
Iodine (53)	I 125 **	S	5×10⁻⁸	4×10⁻⁸	6×10⁻¹²	2×10⁻⁷
		I	2×10⁻⁷	6×10⁻⁸	6×10⁻⁹	2×10⁻⁴
	I 126	S	8×10⁻⁸	5×10⁻³	9×10⁻¹¹	3×10⁻⁷
		I	3×10⁻⁷	3×10⁻³	1×10⁻⁸	9×10⁻⁴
	I 129	S	2×10⁻⁸	1×10⁻³	2×10⁻¹²	9×10⁻⁸
		I	7×10⁻⁸	6×10⁻³	2×10⁻⁹	2×10⁻⁴
	I 131	S	9×10⁻⁸	6×10⁻⁴	1×10⁻¹⁰	2×10⁻⁷
		I	3×10⁻⁷	2×10⁻³	1×10⁻⁸	6×10⁻⁴
	I 132	S	2×10⁻⁷	2×10⁻³	2×10⁻⁸	8×10⁻⁴
		I	9×10⁻⁷	5×10⁻³	3×10⁻⁸	2×10⁻³
	I 133	S	3×10⁻⁸	2×10⁻⁴	4×10⁻¹⁰	6×10⁻⁸
		I	2×10⁻⁷	1×10⁻³	7×10⁻⁹	4×10⁻⁴
	I 134	S	5×10⁻⁷	4×10⁻³	6×10⁻⁹	2×10⁻³
		I	3×10⁻⁸	2×10⁻³	1×10⁻⁹	6×10⁻⁴
	I 135	S	1×10⁻⁷	7×10⁻⁴	1×10⁻⁹	4×10⁻⁴
		I	4×10⁻⁷	2×10⁻³	1×10⁻⁸	7×10⁻⁴
Iridium (77)	Ir 190	S	1×10⁻⁶	6×10⁻³	4×10⁻⁸	2×10⁻⁶
		I	4×10⁻⁷	5×10⁻³	1×10⁻⁸	2×10⁻⁶
	Ir 192	S	1×10⁻⁷	1×10⁻³	4×10⁻⁹	4×10⁻⁴
		I	3×10⁻⁸	1×10⁻³	9×10⁻¹⁰	4×10⁻⁴
	Ir 194	S	2×10⁻⁷	1×10⁻³	8×10⁻⁹	3×10⁻⁴
		I	2×10⁻⁷	9×10⁻⁴	5×10⁻⁹	3×10⁻⁴
Iron (26)	Fe 55	S	9×10⁻⁷	2×10⁻³	3×10⁻⁸	6×10⁻⁴
		I	1×10⁻⁶	7×10⁻³	3×10⁻⁸	2×10⁻³
	Fe 59	S	1×10⁻⁷	2×10⁻³	5×10⁻⁹	6×10⁻⁴
		I	5×10⁻⁹	2×10⁻³	2×10⁻⁸	5×10⁻³
Krypton [3] (36)	Kr 85m	Sub	6×10⁻⁶	----------	1×10⁻⁷	----------
	Kr 85	Sub	1×10⁻⁵	----------	3×10⁻⁷	----------
	Kr 87	Sub	1×10⁻⁶	----------	2×10⁻⁸	----------

See footnotes at end of table.

*Revised 29 FR 14434

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Krypton (36)	Kr 88 **	sub	1×10⁻⁶	----------	2×10⁻⁸	----------
Lanthanum (57)	La 140	S	2×10⁻⁷	7×10⁻⁴	8×10⁻⁹	2×10⁻⁴
		I	1×10⁻⁷	7×10⁻⁴	4×10⁻⁹	2×10⁻⁴
Lead (82)	Pb 203	S	3×10⁻⁶	1×10⁻³	9×10⁻⁸	4×10⁻⁴
		I	2×10⁻⁶	1×10⁻³	6×10⁻⁸	4×10⁻⁴
	Pb 210	S	1×10⁻¹⁰	4×10⁻³	4×10⁻¹²	1×10⁻⁶
		I	2×10⁻¹⁰	5×10⁻³	6×10⁻¹²	2×10⁻⁶
	Pb 212	S	2×10⁻⁶	6×10⁻³	6×10⁻⁸	2×10⁻⁶
		I	2×10⁻⁶	5×10⁻³	7×10⁻⁸	2×10⁻⁶
Lutetium (71)	Lu 177	S	6×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
		I	5×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
Manganese (25)	Mn 52	S	2×10⁻⁷	1×10⁻³	7×10⁻⁹	3×10⁻⁴
		I	1×10⁻⁷	9×10⁻⁴	5×10⁻⁹	3×10⁻⁴
	Mn 54	S	4×10⁻⁷	4×10⁻³	1×10⁻⁸	1×10⁻⁴
		I	4×10⁻⁷	3×10⁻³	1×10⁻⁸	1×10⁻⁴
	Mn 56	S	8×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻⁴
		I	5×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
Mercury (80)	Hg 197m	S	7×10⁻⁷	6×10⁻³	3×10⁻⁸	2×10⁻⁴
		I	8×10⁻⁷	5×10⁻³	3×10⁻⁸	2×10⁻⁴
	Hg 197	S	1×10⁻⁶	9×10⁻³	4×10⁻⁸	3×10⁻⁴
		I	3×10⁻⁶	1×10⁻²	9×10⁻⁸	5×10⁻⁴
	Hg 203	S	7×10⁻⁷	5×10⁻³	2×10⁻⁸	2×10⁻⁴
		I	1×10⁻⁷	8×10⁻³	4×10⁻⁹	1×10⁻⁴
Molybdenum (42)	Mo 99	S	7×10⁻⁷	5×10⁻³	3×10⁻⁸	2×10⁻⁴
		I	2×10⁻⁷	1×10⁻³	7×10⁻⁹	4×10⁻⁴
Neodymium (60)	Nd 144	S	6×10⁻¹¹	2×10⁻³	8×10⁻¹²	7×10⁻⁶
		I	3×10⁻¹⁰	2×10⁻³	1×10⁻¹¹	6×10⁻⁴
	Nd 147	S	4×10⁻⁷	2×10⁻³	1×10⁻⁸	6×10⁻⁴
		I	2×10⁻⁷	2×10⁻³	8×10⁻⁹	6×10⁻⁴
	Nd 149	S	2×10⁻⁶	6×10⁻³	8×10⁻⁸	3×10⁻³
		I	1×10⁻⁶	6×10⁻³	5×10⁻⁸	3×10⁻³
Neptunium (93)	Np 237	S	4×10⁻¹⁰	9×10⁻³	1×10⁻¹²	3×10⁻⁶
		I	1×10⁻¹⁰	9×10⁻³	4×10⁻¹²	3×10⁻⁶
	Np 239	S	8×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻⁴
		I	7×10⁻⁷	4×10⁻³	2×10⁻⁸	1×10⁻⁴
Nickel (28)	Ni 59	S	5×10⁻⁷	6×10⁻³	2×10⁻⁸	2×10⁻⁴
		I	3×10⁻⁷	6×10⁻³	1×10⁻⁸	2×10⁻⁴
	Ni 63	S	8×10⁻⁷	6×10⁻³	3×10⁻⁸	2×10⁻⁴
		I	3×10⁻⁷	2×10⁻³	1×10⁻⁸	7×10⁻⁵
	Ni 65	S	9×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻⁴
		I	5×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
Niobium (Columbium) (41)	Nb 93m	S	1×10⁻⁷	1×10⁻³	4×10⁻⁹	4×10⁻⁴
		I	2×10⁻⁷	1×10⁻³	5×10⁻⁹	4×10⁻⁴
	Nb 95	S	8×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
		I	1×10⁻⁷	3×10⁻³	3×10⁻⁹	1×10⁻⁴
	Nb 97	S	9×10⁻⁶	3×10⁻³	2×10⁻⁷	9×10⁻⁴
		I	8×10⁻⁶	3×10⁻³	2×10⁻⁷	9×10⁻⁴
Osmium (76)	Os 185	S	8×10⁻⁷	2×10⁻³	2×10⁻⁸	7×10⁻⁴
		I	5×10⁻⁸	2×10⁻³	2×10⁻⁸	7×10⁻⁴
	Os 191m	S	2×10⁻⁵	7×10⁻³	8×10⁻⁷	3×10⁻³
		I	9×10⁻⁶	7×10⁻³	3×10⁻⁷	2×10⁻³
	Os 191	S	1×10⁻⁶	5×10⁻³	4×10⁻⁸	2×10⁻³
		I	4×10⁻⁷	5×10⁻³	1×10⁻⁸	2×10⁻³
	Os 193	S	4×10⁻⁷	2×10⁻³	1×10⁻⁸	6×10⁻⁴
		I	3×10⁻⁷	2×10⁻³	9×10⁻⁹	5×10⁻⁴
Palladium (46)	Pd 103	S	1×10⁻⁶	1×10⁻³	5×10⁻⁸	3×10⁻⁴
		I	7×10⁻⁷	6×10⁻³	3×10⁻⁸	3×10⁻⁴
	Pd 109	S	8×10⁻⁷	3×10⁻³	2×10⁻⁸	9×10⁻⁴
		I	4×10⁻⁷	2×10⁻³	1×10⁻⁸	7×10⁻⁴
Phosphorus (15)	P 32	S	7×10⁻⁶	5×10⁻³	2×10⁻⁸	2×10⁻⁴
		I	8×10⁻⁶	7×10⁻³	3×10⁻⁸	2×10⁻⁴
Platinum (78)	Pt 191	S	8×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻⁴
		I	6×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
	Pt 193m	S	7×10⁻⁶	3×10⁻²	2×10⁻⁷	1×10⁻³
		I	5×10⁻⁶	3×10⁻²	2×10⁻⁷	1×10⁻³
	Pt 197m	S	6×10⁻⁶	3×10⁻²	2×10⁻⁷	1×10⁻³
		I	5×10⁻⁶	3×10⁻²	2×10⁻⁷	9×10⁻⁴
	Pt 197	S	9×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻⁴
		I	6×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
Plutonium (94)	Pu 238	S	2×10⁻¹³	1×10⁻⁴	7×10⁻¹⁵	5×10⁻⁹
		I	3×10⁻¹¹	6×10⁻⁴	1×10⁻¹²	3×10⁻⁴
	Pu 239	S	2×10⁻¹³	1×10⁻⁴	6×10⁻¹⁵	5×10⁻⁹
		I	4×10⁻¹¹	8×10⁻⁴	1×10⁻¹²	3×10⁻⁴

**Added 30 FR 15801

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Plutonium (94)	Pu 240	S I S I S I	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
	Pu 241		4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 242		9×10^{-13}	7×10^{-5}	3×10^{-13}	2×10^{-6}
	Pu 243		4×10^{-8}	4×10^{-3}	1×10^{-9}	1×10^{-3}
	Pu 244		2×10^{-13}	1×10^{-4}	6×10^{-15}	5×10^{-6}
***			2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
			3×10^{-21}	3×10^{-8}	1×10^{-23}	1×10^{-9}
Polonium (84)	Po 210	S I S I S I	5×10^{-10}	2×10^{-3}	2×10^{-11}	7×10^{-7}
Potassium (19)	K42	S I S I S I	2×10^{-10}	8×10^{-6}	7×10^{-12}	3×10^{-4}
Praseodymium (59)	Pr 142	S I S I S I	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
	Pr 143	S I S I S I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
			2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
			3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
Promethium (61)	Pm 147	S I S I S I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
	Pm 149	S I S I S I	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
			1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
			3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
Protoactinium (91)	Pa 230	S I S I S I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
	Pa 231	S I S I S I	2×10^{-9}	7×10^{-3}	6×10^{-11}	2×10^{-4}
			8×10^{-10}	7×10^{-3}	3×10^{-11}	2×10^{-4}
			1×10^{-12}	3×10^{-5}	4×10^{-14}	9×10^{-7}
			1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Pa 233	S I S I S I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
			2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
* Radium (88)	Ra 223	S I S I S I	2×10^{-9}	2×10^{-5}	6×10^{-11}	7×10^{-7}
	Ra 224	S I S I S I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
			5×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
	Ra 226	S I S I S I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}
			3×10^{-11}	4×10^{-7}	9×10^{-13}	3×10^{-8}
	Ra 228	S I S I S I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
			7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-9}
			4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S I S I S I	3×10^{-7}	.....	1×10^{-9}	.....
	Rn 222	S I S I S I	1×10^{-7}	.....	3×10^{-9}	.....
Rhenium (75)	Re 183	S I S I S I	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
	Re 186	S I S I S I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
			6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Re 187	S I S I S I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-3}
			9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
	Re 188	S I S I S I	5×10^{-7}	4×10^{-2}	2×10^{-8}	2×10^{-3}
			4×10^{-7}	2×10^{-2}	1×10^{-8}	6×10^{-4}
			2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S I S I S I	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
	Rh 105	S I S I S I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
			8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S I S I S I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
	Rb 87	S I S I S I	7×10^{-6}	7×10^{-4}	2×10^{-7}	2×10^{-5}
			5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-4}
Ruthenium (44)	Ru 97	S I S I S I	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
	Ru 103	S I S I S I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
			5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
	Ru 105	S I S I S I	8×10^{-6}	2×10^{-3}	3×10^{-8}	8×10^{-5}
			7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S I S I S I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			8×10^{-8}	4×10^{-4}	3×10^{-9}	1×10^{-5}
			6×10^{-8}	3×10^{-4}	2×10^{-10}	1×10^{-3}
Samarium (62)	Sm 147	S I S I S I	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-3}
	Sm 151	S I S I S I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-3}
			6×10^{-8}	1×10^{-2}	2×10^{-9}	4×10^{-4}
	Sm 153	S I S I S I	1×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
			5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
			4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Scandium (21)	Sc 46	S I S I S I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
	Sc 47	S I S I S I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
	Sc 48	S I S I S I	6×10^{-8}	3×10^{-3}	2×10^{-9}	9×10^{-5}
			5×10^{-8}	3×10^{-3}	2×10^{-9}	9×10^{-5}
			2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
Selenium (34)	Se 75	S I S I S I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
			1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
Silicon (14)	Si 31	S I S I S I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-4}
			6×10^{-8}	3×10^{-3}	2×10^{-9}	9×10^{-5}
			1×10^{-6}	6×10^{-3}	3×10^{-8}	2×10^{-4}
Silver (47)	Ag 105	S I S I S I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ag 110m	S I S I S I	8×10^{-7}	3×10^{-3}	3×10^{-8}	1×10^{-4}
			2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
	Ag 111	S I S I S I	1×10^{-7}	9×10^{-4}	3×10^{-10}	3×10^{-5}
			3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
			2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Sodium (11)	Na 22	S I S I S I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Na 24	S I S I S I	9×10^{-8}	9×10^{-4}	3×10^{-10}	3×10^{-5}
			1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
* Strontium (38)	Sr 85m	S I S I S I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sr 85	S I S I S I	4×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
			3×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
	Sr 89	S I S I S I	2×10^{-7}	3×10^{-5}	8×10^{-9}	1×10^{-6}
			1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
	Sr 90	S I S I S I	3×10^{-8}	3×10^{-6}	1×10^{-9}	1×10^{-7}
			4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
			** 1×10^{-9}	1×10^{-6}	3×10^{-11}	3×10^{-7}
	Sr 91	S I S I S I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-6}
			4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
	Sr 92	S I S I S I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
			4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
			3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Sulfur (16)	S 35	S I S I S I	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
			3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-4}
Tantalum (73)	Ta 182	S I S I S I	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
			2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Technetium (43)	Tc 96m	S I S I S I	8×10^{-3}	4×10^{-1}	3×10^{-6}	1×10^{-2}
	Tc 96	S I S I S I	3×10^{-3}	3×10^{-1}	1×10^{-4}	1×10^{-2}
			6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Tc 97m	S I S I S I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
			2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
	Tc 97	S I S I S I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
			1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Tc 99m	S I S I S I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
			4×10^{-7}	2×10^{-1}	1×10^{-8}	6×10^{-3}
	Tc 99	S I S I S I	1×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
			2×10^{-6}	1×10^{-3}	7×10^{-8}	3×10^{-4}
			6×10^{-9}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S I S I S I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
			1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S I S I S I	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
			4×10^{-6}	2×10^{-3}	1×10^{-7}	5×10^{-5}
	Te 127	S I S I S I	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
			9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S I S I S I	8×10^{-7}	1×10^{-3}	3×10^{-8}	3×10^{-5}
			3×10^{-7}	6×10^{-4}	1×10^{-8}	2×10^{-5}
	Te 129	S I S I S I	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
			4×10^{-6}	2×10^{-3}	1×10^{-7}	8×10^{-4}
	Te 131m	S I S I S I	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
			2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S I S I S I	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
			1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S I S I S I	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
			3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S I S I S I	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-4}
			1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S I S I S I	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
			9×10^{-7}	5×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 202	S I S I S I	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
			2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S I S I S I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}

*Revised 29 FR 14434

**Revised 30 FR 15801

*** Added 30 FR 15801

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]	Table I		Table II	
		Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
Zirconium (40)	Zr 93	1X10⁻⁷	2X10⁻⁴	4X10⁻⁹	8X10⁻⁷
		3X10⁻⁷	2X10⁻³	1X10⁻⁸	8X10⁻⁶
	Zr 95	1X10⁻⁷	2X10⁻³	4X10⁻⁹	6X10⁻⁸
		3X10⁻⁸	2X10⁻³	1X10⁻⁹	6X10⁻⁸
	Zr 97	1X10⁻⁷	5X10⁻⁴	4X10⁻⁹	2X10⁻⁵
		9X10⁻⁸	5X10⁻⁴	3X10⁻⁹	2X10⁻⁵
		1X10⁻⁶	1X10⁻³	3X10⁻⁸	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hour.	Sub				
* Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hour.		3X10⁻⁹	9X10⁻⁶	1X10⁻¹⁰	3X10⁻⁷
* Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.		6X10⁻¹⁰	4X10⁻⁷	2X10⁻¹¹	3X10⁻⁸

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]	Table I		Table II	
		Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
Thorium (90)	Th 228	9X10⁻¹²	2X10⁻⁴	3X10⁻¹²	7X10⁻⁵
	Th 230	6X10⁻¹²	4X10⁻⁴	2X10⁻¹²	1X10⁻⁴
	Th 232	2X10⁻¹¹	5X10⁻⁴	9X10⁻¹³	2X10⁻⁴
	Th natural	3X10⁻¹¹	9X10⁻⁴	3X10⁻¹³	3X10⁻⁴
	Th 234	3X10⁻¹¹	3X10⁻³	1X10⁻¹²	1X10⁻³
Thulium (69)	Tm 170	3X10⁻⁹	6X10⁻⁴	2X10⁻¹⁰	2X10⁻⁴
		4X10⁻⁹	1X10⁻³	1X10⁻¹⁰	5X10⁻⁴
	Tm 171	3X10⁻⁷	1X10⁻²	1X10⁻⁸	4X10⁻³
		1X10⁻⁷	1X10⁻²	4X10⁻⁹	4X10⁻³
Tin (50)	Sn 113	2X10⁻⁷	2X10⁻³	7X10⁻⁹	1X10⁻³
		4X10⁻⁷	2X10⁻³	1X10⁻⁸	6X10⁻⁴
	Sn 125	5X10⁻⁸	5X10⁻⁴	2X10⁻⁹	1X10⁻⁴
		1X10⁻⁷	5X10⁻⁴	4X10⁻⁹	1X10⁻⁴
Tungsten (Wolfram) (74)	W 181	8X10⁻⁷	1X10⁻²	3X10⁻⁸	4X10⁻³
		2X10⁻⁷	1X10⁻²	7X10⁻⁹	4X10⁻³
	W 185	1X10⁻⁷	4X10⁻³	4X10⁻⁹	1X10⁻³
		4X10⁻⁷	1X10⁻²	1X10⁻⁸	4X10⁻³
	W 187	3X10⁻⁷	2X10⁻³	1X10⁻⁸	6X10⁻⁴
Uranium (92)	U 230	3X10⁻¹⁰	1X10⁻⁴	1X10⁻¹¹	3X10⁻⁵
		1X10⁻⁹	4X10⁻⁴	4X10⁻¹¹	1X10⁻⁴
	U 232	3X10⁻¹⁰	1X10⁻⁴	1X10⁻¹¹	3X10⁻⁵
		1X10⁻⁹	4X10⁻⁴	4X10⁻¹¹	1X10⁻⁴
	U 233	5X10⁻¹⁰	2X10⁻⁴	2X10⁻¹¹	6X10⁻⁵
		2X10⁻⁹	6X10⁻⁴	7X10⁻¹¹	2X10⁻⁴
	U 234	6X10⁻¹⁰	2X10⁻⁴	2X10⁻¹¹	6X10⁻⁵
		2X10⁻⁹	6X10⁻⁴	7X10⁻¹¹	2X10⁻⁴
	U 235	5X10⁻¹⁰	2X10⁻⁴	2X10⁻¹¹	6X10⁻⁵
		2X10⁻⁹	6X10⁻⁴	7X10⁻¹¹	2X10⁻⁴
	U 236	6X10⁻¹⁰	2X10⁻⁴	2X10⁻¹¹	6X10⁻⁵
		2X10⁻⁹	6X10⁻⁴	7X10⁻¹¹	2X10⁻⁴
	U 238	1X10⁻⁹	4X10⁻⁴	3X10⁻¹¹	1X10⁻⁴
		1X10⁻⁸	3X10⁻³	5X10⁻¹¹	2X10⁻³
*	U 240	8X10⁻⁷	1X10⁻²	3X10⁻⁸	4X10⁻³
		2X10⁻⁷	1X10⁻²	8X10⁻⁹	4X10⁻³
	U-natural	1X10⁻⁷	5X10⁻⁴	4X10⁻⁹	2X10⁻⁴
Vanadium (23)	V 48	7X10⁻⁹	9X10⁻⁴	2X10⁻¹⁰	3X10⁻⁴
		6X10⁻⁸	9X10⁻³	2X10⁻⁹	3X10⁻³
Xenon (54)	Xe 131m	2X10⁻⁶	4X10⁻³	6X10⁻⁸	1X10⁻³
	Xe 133	1X10⁻⁶	1X10⁻²	4X10⁻⁸	6X10⁻³
*	Xe 133m	1X10⁻⁶	1X10⁻²	4X10⁻⁸	6X10⁻³
	Xe 135	4X10⁻⁷	2X10⁻³	1X10⁻⁸	8X10⁻⁴
Ytterbium (70)	Yb 175	7X10⁻⁸	3X10⁻³	2X10⁻⁹	1X10⁻³
		6X10⁻⁷	3X10⁻²	2X10⁻⁸	1X10⁻²
Yttrium (39)	Y 90	1X10⁻⁷	6X10⁻⁴	4X10⁻⁹	2X10⁻⁴
		1X10⁻⁷	6X10⁻³	3X10⁻⁸	2X10⁻³
	Y 91m	2X10⁻⁶	1X10⁻²	6X10⁻⁸	4X10⁻³
		2X10⁻⁶	1X10⁻²	6X10⁻⁸	4X10⁻³
	Y 91	4X10⁻⁸	2X10⁻³	1X10⁻⁹	8X10⁻⁴
		3X10⁻⁷	2X10⁻²	1X10⁻⁸	6X10⁻³
	Y 92	3X10⁻⁷	2X10⁻³	1X10⁻⁸	6X10⁻⁴
		2X10⁻⁷	2X10⁻³	6X10⁻⁹	6X10⁻⁴
	Y 93	8X10⁻⁸	5X10⁻⁴	3X10⁻⁹	2X10⁻⁴
		1X10⁻⁷	5X10⁻⁴	4X10⁻⁹	2X10⁻⁴
Zinc (30)	Zn 65	1X10⁻⁷	6X10⁻⁴	4X10⁻⁹	2X10⁻⁴
		6X10⁻⁷	6X10⁻³	2X10⁻⁸	2X10⁻³
	Zn 69m	4X10⁻⁷	2X10⁻³	1X10⁻⁸	8X10⁻⁴
		3X10⁻⁷	2X10⁻³	1X10⁻⁸	6X10⁻⁴
	Zn 69	7X10⁻⁷	5X10⁻³	2X10⁻⁸	2X10⁻³
		9X10⁻⁷	5X10⁻³	3X10⁻⁸	2X10⁻³

*Added 30 FR 15801

December 22, 1965

☆ [3] Soluble (S); Insoluble (I).

[3] "Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's, are MPC_A, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\frac{C_C}{MPC_C}\leq 1$$

☆ 2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix B shall be:

a. For purposes of Table I, Col. 1—6×10^{-13}
b. For purposes of Table I, Col. 2—4×10^{-7}
c. For purposes of Table II, Col 1—2×10^{-14}
d. For purposes of Table II, Col. 2—3×10^{-8}

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "B" for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "B" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "B" for any radionuclide which is not known to be absent from the mixture; or

[26 FR 11046 — 7/01/65]

4. If the mixture of radionuclides consists of uranium and its daughter products in ore dust prior to chemical processing of the uranium ore, the values specified below may be used in lieu of those determined in accordance with paragraph 1 above or those specified in paragraphs 2 and 3 above.

[25 FR 13952]

a. For purposes of Table I, Col. 1—1×10^{-10} μc/ml gross alpha activity; or 2.5×10^{-11} μc/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-12} μc/ml gross alpha activity; or 8×10^{-13} μc/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

[26 FR 11046]

5. For purposes of this Note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix "B" (MPC_A) does not exceed 1/10, (i.e. $\frac{C_A}{MPC_A}\leq\frac{1}{10}$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed ¼ i.e.

$$\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\cdots\cdots\leq\tfrac{1}{4}).$$

[30 FR 15801]

c. Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131, (I 133, table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th 232, Th-nat, Cm 248, Cf 254, and Fm 256 are not present	----------	9×10^{-6}	----------	3×10^{-6}
If it is known that Sr 90, I 125, I 126, I 129, (I 131, I 133, table II only), Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 256 are not present	----------	6×10^{-6}	----------	2×10^{-6}
If it is known that Sr 90, I 129, (I 125, I 126, I 131, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present	----------	2×10^{-6}	----------	6×10^{-7}
If it is known that (I 129, table II only), Ra 226, and Ra 228 are not present	----------	3×10^{-6}	----------	1×10^{-7}
☆☆ If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 240, and Bk 249 are not present	3×10^{-6}	----------	1×10^{-10}	----------
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	3×10^{-10}	----------	1×10^{-11}	----------
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}	----------	1×10^{-12}	----------
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-12}	----------	1×10^{-12}	----------

*Revised 30 FR 15801

**ERRATUM: This line should read: "210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 249 are not"

Appendix B from 25 FR 10914 except as otherwise noted.

APPENDIX C

Material	Microcuries
Ag^{105}	1
Ag^{111}	10
As^{76}, As^{77}	10
Au^{198}	10
Au^{199}	10
$Ba^{140}+La^{140}$	1
Be^{7}	50
C^{14}	50
Ca^{45}	10
$Cd^{109}+Ag^{109}$	10
$Ce^{144}+Pr^{144}$	1
Cl^{36}	1
Co^{60}	1
Cr^{51}	50
$Cs^{137}+Ba^{137}$	1
Cu^{64}	50
Eu^{155}	1
F^{18}	50
Fe^{55}	50
Fe^{59}	1
Ga^{72}	10
Ge^{71}	50
H^3(HTO or H^3_2O)	250
I^{131}	10
In^{115}	1
Ir^{192}	10
K^{42}	10
La^{140}	10
Mn^{56}	1
Mn^{59}	50
Mo^{99}	10
Na^{22}	10
Na^{24}	10
Nb^{95}	10
Ni^{59}	1
Ni^{65}	1
P^{32}	10
$Pd^{109}+Rh^{109}$	50
Pd^{109}	10
Pm^{147}	10
Po^{210}	0.1
Pr^{142}	10
Pu^{239}	1
Ra^{226}	0.1
Rb^{87}	10
Re^{183}	10
Rh^{105}	10
$Ru^{103}+Rh^{103}$	1
S^{35}	50
Sb^{124}	1
Sc^{46}	1
Sm^{153}	10
Sn^{113}	10
Sr^{89}	1
$Sr^{90}+Y^{90}$	0.1
Te^{129}	10
Te^{99}	1
Te^{99}	1
Te^{127}	10
Te^{129}	1
Th (natural)	50
Tl^{204}	50
Tritium. See H^3	250
U (natural)	50
U^{233}	1
U^{234}-U^{238}	50
V^{48}	1
W^{185}	10
Y^{90}	1
Y^{91}	1
Zn^{65}	10
Unidentified radioactive materials or any of the above in unknown mixtures	0.1

NOTE: For purposes of §§ 20.203 and 20.304, where there is involved a combination of isotopes in known amounts the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

EXAMPLE: For purposes of § 20.304, if a particular batch contains 2,000 μc of Au^{198} and 25,000 μc of C^{14}, it may also include not more than 3,000 μc of I^{131}. This limit was determined as follows:

$$\frac{2{,}000\ \mu c\ Au^{198}}{10{,}000\ \mu c} + \frac{25{,}000\ \mu c\ C^{14}}{80{,}000\ \mu c} + \frac{3{,}000\ \mu c\ I^{131}}{10{,}000\ \mu c} = 1$$

The denominator in each of the above ratios was obtained by multiplying the figure in the table by 1,000 as provided in § 20.304.

April 5, 1966

APPENDIX D

UNITED STATES ATOMIC ENERGY COMMISSION

COMPLIANCE OFFICES

Region	Address	Telephone: Daytime	Telephone: Nights and holidays
I Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	Region I, Division of Compliance, USAEC, 376 Hudson St., New York, N.Y., 10014	212-969-1000	212-969-1000
II Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Panama Canal Zone, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	Region II, Division of Compliance, USAEC, 80 7th St. NE., Atlanta, Ga., 30323	404-526-5701	404-526-5701
III Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	Region III, Division of Compliance, USAEC, Suite 410, Oakbrook Professional Bldg., Oak Brook, Ill., 60523	312-654-1680	312-739-7711
IV Colorado, Idaho, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	Region IV, Division of Compliance, USAEC, 10396 West Colfax Ave., Denver, Colo., 80215	303-297-4211	303-237-8086
V Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington and U.S. territories and possessions in the Pacific.	Region V, Division of Compliance, USAEC, 2111 Bancroft Way, Berkeley, Calif., 94704	415-841-8920	415-841-8920

31 FR 4668

NOTE: The record keeping and reporting requirements contained in this part have been approved by the Bureau of the Budget in accordance with the Federal Reports Act of 1942.

Appendix C from 25 FR 10914.

Appendix D from 27 FR 10826.

PART 34

LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHIC OPERATIONS

Sec.
34.1 Purpose and scope.
34.2 Definitions.
34.3 Applications for specific licenses.

Subpart A—Specific Licensing Requirements

34.11 Issuance of specific licenses for use of sealed sources in radiography.

Subpart B—Radiation Safety Requirements

EQUIPMENT CONTROL

34.21 Limit on levels of radiation for radiographic exposure devices and storage containers.
34.22 Locking of radiographic exposure devices and storage containers.
34.23 Storage precautions.
34.24 Radiation survey instruments.
34.25 Leak testing, repair, tagging, opening, modification and replacement of sealed sources.
34.26 Quarterly inventory.
34.27 Utilization logs.

PERSONAL RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHERS AND RADIOGRAPHERS' ASSISTANT

34.31 Limitations.
34.32 Operating and emergency procedures.
34.33 Personnel monitoring control.

PRECAUTIONARY PROCEDURES IN RADIOGRAPHIC OPERATIONS

34.41 Security.
34.42 Posting.
34.43 Radiation surveys and survey records.

EXEMPTIONS

34.51 Applications for exemptions.
Appendix A.

30 FR 8185

§ 34.1 Purpose and scope.

This part prescribes requirements for the issuance of licenses for the use of sealed sources containing byproduct material and radiation safety requirements for persons using such sealed sources in radiography. The provisions and requirements of this part are in addition to, and not in substitution for, other requirements of this chapter. In particular, the provisions of Part 30 of this chapter apply to applications and licenses subject to this part. Nothing in this part shall apply to uses of byproduct material for medical diagnosis or therapy.

§ 34.2 Definitions.

As used in this part:

(a) "Radiography" means the examination of the structure of materials by nondestructive methods, utilizing sealed sources of byproduct materials;

(b) "Radiographer" means any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic operations and who is responsible to the licensee for assuring compliance with the requirements of the Commission's regulations and the conditions of the license;

(c) "Radiographer's assistant" means any individual who, under the personal supervision of a radiographer, uses radiographic exposure devices, sealed sources or related handling tools, or radiation survey instruments in radiography;

(d) "Radiographic exposure device" means any instrument containing a sealed source fastened or contained therein, in which the sealed source or shielding thereof may be moved, or otherwise changed, from a shielded to unshielded position for purposes of making a radiographic exposure;

(e) "Sealed source" means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material;

(f) "Storage container" means a device in which sealed sources are transported or stored.

§ 34.3 Applications for specific licenses.

Applications for specific licenses for use of sealed sources in radiography shall be filed on Form AEC 313R, "Application for Byproduct Material License—Use of Sealed Sources in Radiography."

Subpart A—Specific Licensing Requirements

§ 34.11 Issuance of specific licenses for use of sealed sources in radiography.

An application for a specific license for use of sealed sources in radiography will be approved if:

(a) The applicant satisfies the general requirements specified in § 30.33 of this chapter;

(b) The applicant will have an adequate program for training radiographers and radiographers' assistants and submits to the Commission a schedule or description of such program which specifies the:

(1) Initial training;

(2) Periodic training;

(3) On-the-job training;

(4) Means to be used by the licensee to determine the radiographer's knowledge and understanding of and ability to comply with Commission regulations and licensing requirements, and the operating and emergency procedures of the applicant; and

(5) Means to be used by the licensee to determine the radiographer's assistant's knowledge and understanding of and ability to comply with the operating and emergency procedures of the applicant;

(c) The applicant has established and submits to the Commission satisfactory written operating and emergency procedures as described in § 34.32;

(d) The applicant will have an adequate internal inspection system, or other management control, to assure that Commission license provisions, Commission regulations, and the applicant's operating and emergency procedures are followed by radiographers and radiographers' assistants;

(e) The applicant submits a description of its over-all organizational structure pertaining to the radiography program, including specified delegations of authority and responsibility for operation of the program; and

(f) The applicant who desires to conduct his own leak tests has established adequate procedures to be followed in leak testing sealed sources, for possible leakage and contamination and submits to the Commission a description of such procedures including:

(1) Instrumentation to be used,

(2) Method of performing test, e.g., points on equipment to be smeared and method of taking smear, and

(3) Pertinent experience of the person who will perform the test.

Subpart B—Radiation Safety Requirements

Equipment Control

§ 34.21 Limits on levels of radiation for radiographic exposure devices and storage containers.

Radiographic exposure devices measuring less than four (4) inches from the sealed source storage position to any exterior surface of the device shall have no radiation level in excess of 50 milliroentgens per hour at six (6) inches from any exterior surface of the device. Radiographic exposure devices measuring a minimum of four (4) inches from the sealed source storage position to any exterior surface of the device, and all storage containers for sealed sources or for radiographic exposure devices, shall have no radiation level in excess of 200 milliroentgens per hour at any exterior surface, and ten (10) milliroentgens per hour at one meter from any exterior surface. The radiation levels specified are with the sealed source in the shielded (i.e., "off") position.

§ 34.22 Locking of radiographic exposure devices and storage containers.

30 FR 8185

Each radiographic exposure device shall be provided with a lock or outer locked container designed to prevent unauthorized or accidental removal or exposure of a sealed source and shall be kept locked at all times except when under the direct surveillance of a radiographer or radiographer's assistant, or as may be otherwise authorized pursuant to § 34.41. Each storage container likewise shall be provided with a lock and kept locked when containing sealed sources except when the container is under the direct surveillance of a radiographer or radiographer's assistant.

§ 34.23 Storage precautions.

Locked radiographic exposure devices and storage containers shall be physically secured to prevent tampering or removal by unauthorized personnel.

§ 34.24 Radiation survey instruments.

The licensee shall maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys as required by this part and Part 20 of this chapter. Each radiation survey instrument shall be calibrated at intervals not to exceed three (3) months and after each instrument servicing and a record maintained of the latest date of calibration. Instrumentation required by this section shall have a range such that two milliroentgens per hour through one roentgen per hour can be measured.

§ 34.25 Leak testing, repair, tagging, opening, modification and replacement of sealed sources.

(a) The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing, repair, tagging, opening or any other modification of any sealed source shall be performed only by persons specifically authorized by the Commission to do so.

(b) Each sealed source shall be tested for leakage at intervals not to exceed 6 months. In the absence of a certificate from a transferor that a test has been made within the 6 months prior to the transfer, the sealed source shall not be put into use until tested.

(c) The leak test shall be capable of detecting the presence of 0.005 microcurie of removable contamination on the sealed source. An acceptable leak test for sealed sources in the possession of a radiography licensee would be to test at the nearest accessible point to the sealed source storage position, or other appropriate measuring point, by a procedure to be approved pursuant to § 34.11 (f). Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Commission.

(d) Any test conducted pursuant to paragraphs (b) and (c) of this section which reveals the presence of 0.005 microcurie or more of removable radioactive material shall be considered evidence that the sealed source is leaking. The licensee shall immediately withdraw the equipment involved from use and shall cause it to be decontaminated and repaired or to be disposed of, in accordance with Commission regulations. A report shall be filed, within 5 days of the test, with the Director, Division of Materials Licensing, U.S. Atomic Energy Commission, Washington, D.C., 20545, describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall be sent to the Director of the appropriate Atomic Energy Commission Regional Compliance Office listed in Appendix D of Part 20 of this chapter "Standards for Protection Against Radiation."

(e) A sealed source which is not fastened to or contained in a radiographic exposure device shall have permanently attached to it a durable tag at least one (1) inch square bearing the prescribed radiation caution symbol in conventional colors, magenta or purple on a yellow background, and at least the instructions: "Danger—Radioactive Material—Do Not Handle—Notify Civil Authorities if Found."

§ 34.26 Quarterly inventory.

Each licensee shall conduct a quarterly physical inventory to account for all sealed sources received and possessed under his license. The records of the inventories shall be maintained for inspection by the Commission, and shall include the quantities and kinds of byproduct material, location of sealed sources, and the date of the inventory.

§ 34.27 Utilization logs.

Each licensee shall maintain current logs, which shall be kept available for inspection by the Commission at the address specified in the license, showing for each sealed source the following information:

(a) A description (or make and model number) of the radiographic exposure device or storage container in which the sealed source is located;

(b) The identity of the radiographer to whom assigned; and

(c) The plant or site where used and dates of use.

Personal Radiation Safety Requirements for Radiographers and Radiographers' Assistants

§ 34.31 Limitations.

(a) The licensee shall not permit any person to act as a radiographer until such person:

(1) Has been instructed in the subjects outlined in Appendix A of this part and shall have demonstrated understanding thereof;

(2) Has received copies of and instruction in the regulations contained in this part and the applicable sections of Part 20 of this chapter, AEC license(s), and the licensee's operating and emergency procedures, and shall have demonstrated understanding thereof; and

(3) Has demonstrated competence to use the radiographic exposure devices, sealed sources, related handling tools and survey instruments which will be employed in his assignment.

(b) The licensee shall not permit any person to act as a radiographer's assistant until such person:

(1) Has received copies of and instructions in the licensee's operating and emergency procedures, and shall have demonstrated understanding thereof; and

(2) Has demonstrated competence to use under the personal supervision of the radiographer the radiographic exposure devices, sealed sources, related handling tools and radiation survey instruments which will be employed in his assignment.

§ 34.32 Operating and emergency procedures.

The licensee's operating and emergency procedures shall include instructions in at least the following:

(a) The handling and use of licensed sealed sources and radiographic exposure devices to be employed such that no person is likely to be exposed to radiation doses in excess of the limits established in Part 20 of this chapter "Standards for Protection Against Radiation";

(b) Methods and occasions for conducting radiation surveys;

(c) Methods for controlling access to radiographic areas;

(d) Methods and occasions for locking and securing radiographic exposure devices, storage containers and sealed sources;

PART 34 - LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY, ETC.

(e) Personnel monitoring and the use of personnel monitoring equipment;

(f) Transporting sealed sources to field locations, including packing of radiographic exposure devices and storage containers in the vehicles, posting of vehicles and control of the sealed sources during transportation;

(g) Minimizing exposure of persons in the event of an accident;

(h) The procedure for notifying proper persons in the event of an accident; and

(i) Maintenance of records.

§ 34.33 Personnel monitoring control.

(a) The licensee shall not permit any person to act as a radiographer or as a radiographer's assistant unless, at all times during radiographic operations, each such person shall wear a film badge and either a pocket dosimeter or pocket chamber. Pocket dosimeters and pocket chambers shall be capable of measuring doses from zero to at least 200 milliroentgens. A film badge shall be assigned to and worn by only one person.

(b) Pocket dosimeters and pocket chambers shall be read and doses recorded daily. A film badge shall be immediately processed if a pocket chamber or pocket dosimeter is discharged beyond its range. The film badge reports received from the film badge processor and records of pocket dosimeter and pocket chamber readings shall be maintained for inspection by the Commission.

30 FR 8185

Precautionary Procedures in Radiographic Operations

§ 34.41 Security.

During each radiographic operation the radiographer or radiographer's assistant shall maintain a direct surveillance of the operation to protect against unauthorized entry into a high radiation area, as defined in Part 20 of this chapter, except (a) where the high radiation area is equipped with a control device or an alarm system as described in § 20.203(c)(2) of this chapter, or (b) where the high radiation area is locked to protect against unauthorized or accidental entry.

§ 34.42 Posting.

Notwithstanding any provisions in § 20.204(c) of this chapter, areas in which radiography is being performed shall be conspicuously posted as required by § 20.203 (b) and (c)(1) of this chapter.

§ 34.43 Radiation surveys and survey records.

(a) No radiographic operation shall be conducted unless calibrated and operable radiation survey instrumentation as described in § 34.24 is available and used at each site where radiographic exposures are made.

(b) A physical radiation survey shall be made after each radiographic exposure during a radiographic operation to determine that the sealed source has been returned to its shielded condition.

(c) A physical radiation survey shall be made to determine that each sealed source is in its shielded condition prior to securing the radiographic exposure device and storage container as specified in § 34.22.

(d) Records shall be kept of the surveys required by paragraph (c) of this section and maintained for inspection by the Commission.

Exemptions

§ 34.51 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

Appendix A

I. Fundamentals of radiation safety.
A. Characteristics of gamma radiation.
B. Units of radiation dose (mrem) and quantity of radioactivity (curie).
C. Hazards of excessive exposure of radiation.
D. Levels of radiation from licensed material.
E. Methods of controlling radiation dose.
1. Working time.
2. Working distances.
3. Shielding.
II. Radiation detection instrumentation to be used.
A. Use of radiation survey instruments.
1. Operation.
2. Calibration.
3. Limitations.
B. Survey techniques.
C. Use of personnel monitoring equipment.
1. Film badges.
2. Pocket dosimeters.
3. Pocket chambers.
III. Radiographic equipment to be used.
A. Remote handling equipment.
B. Radiographic exposure devices.
C. Storage containers.
IV. The requirements of pertinent Federal Regulations.
V. The licensee's written operating and emergency procedures.

Cross Reference Table

New section	*Old section*
34.1	New
34.2	31.3 (a)-(f)
34.3	New
34.11	30.24(g)
34.21	31.101
34.22	31.102
34.23	31.103
34.24	31.104
34.25	31.105
34.26	31.106
34.27	31.107
34.31	31.201
34.32	31.202
34.33	31.203
34.41	31.301
34.42	31.302
34.43	31.303
34.51	31.401
Appendix A	Appendix A, Part 31

June 29, 1965

GPO 906-830

Information Sheet on RADIOGRAPHY FORMULAS AND EQUATIONS

1. $EF \times D^2 = T$ (Exposure time)

2. $\frac{T_1}{T_2} = \frac{D_1^2}{D_2^2}$

3. $\frac{MAS\ 1}{MAS\ 2} = \frac{D_2^2}{D_1^2}$

4. $\frac{I1}{I2} = \frac{D_2^2}{D_1^2}$

5. $\frac{TS}{D^2} = EF$

Where:

FF or EF = Film factor or exposure factor
D = Distance (source to film)
I = Radiation intensity
T = Time (exposure time)
TS = Time x source strength

Some rules involving algebraic expressions:

Monomial - Algebraic expression with one term
Binomial - Algebraic expression with two terms
Polynomial - Algebraic expression with two or more terms
Algebraic expressions - Group of literal numbers and symbols that stand for a number
Term - Algebraic expression whose parts are not separated by plus or minus signs
Symbols - Plus, minus signs
Literal number - Letter that stands for a number
Absolute value of a signed number - The value of a signed number
Negative number - Shows minus sign before number
Signed number - Shows plus or minus before number

Information
Sheet # 5

Information Sheet
on
TABLES OF SQUARES AND SQUARE ROOTS OF NUMBERS FROM 1-800

Number	Square	Square root	Number	Square	Square root
1	1	1.0000	41	16 81	6.4031
2	4	1.4142	42	17 64	6.4807
3	9	1.7321	43	18 49	6.5574
4	16	2.0000	44	19 36	6.6332
5	25	2.2361	45	20 25	6.7082
6	36	2.4495	46	21 16	6.7823
7	49	2.6458	47	22 09	6.8557
8	64	2.8284	48	23 04	6.9282
9	81	3.0000	49	24 01	7.0000
10	1 00	3.1623	50	25 00	7.0711
11	1 21	3.3166	51	26 01	7.1414
12	1 44	3.4641	52	27 04	7.2111
13	1 69	3.6056	53	28 09	7.2801
14	1 96	3.7417	54	29 16	7.3485
15	2 25	3.8730	55	30 25	7.4162
16	2 56	4.0000	56	31 36	7.4833
17	2 89	4.1231	57	32 49	7.5498
18	3 24	4.2426	58	33 64	7.6158
19	3 61	4.3589	59	34 81	7.6811
20	4 00	4.4721	60	36 00	7.7460
21	4 41	4.5826	61	37 21	7.8102
22	4 84	4.6904	62	38 44	7.8740
23	5 29	4.7958	63	39 69	7.9373
24	5 76	4.8990	64	40 96	8.0000
25	6 25	5.0000	65	42 25	8.0623
26	6 76	5.0990	66	43 56	8.1240
27	7 29	5.1962	67	44 89	8.1854
28	7 84	5.2915	68	46 24	8.2462
29	8 41	5.3852	69	47 61	8.3066
30	9 00	5.4772	70	49 00	8.3666
31	9 61	5.5678	71	50 41	8.4261
32	10 24	5.6569	72	51 84	8.4853
33	10 89	5.7446	73	53 29	8.5440
34	11 56	5.8310	74	54 76	8.6023
35	12 25	5.9161	75	56 25	8.6603
36	12 96	6.0000	76	57 76	8.7178
37	13 69	6.0828	77	59 29	8.7750
38	14 44	6.1644	78	60 84	8.8318
39	15 21	6.2450	79	62 41	8.8882
40	16 00	6.3246	80	64 00	8.9443

Number	Square	Square root	Number	Square	Square root
81	65 61	9.0000	121	1 46 41	11.0000
82	67 24	9.0554	122	1 48 84	11.0454
83	68 89	9.1104	123	1 51 29	11.0905
84	70 56	9.1652	124	1 53 76	11.1355
85	72 25	9.2195	125	1 56 25	11.1803
86	73 96	9.2736	126	1 58 76	11.2250
87	75 69	9.3274	127	1 61 29	11.2694
88	77 44	9.3808	128	1 63 84	11.3137
89	79 21	9.4340	129	1 66 41	11.3578
90	81 00	9.4868	130	1 69 00	11.4018
91	82 81	9.5394	131	1 71 61	11.4455
92	84 64	9.5917	132	1 74 24	11.4891
93	86 49	9.6437	133	1 76 89	11.5326
94	88 36	9.6954	134	1 79 56	11.5758
95	90 25	9.7468	135	1 82 25	11.6190
96	92 16	9.7980	136	1 84 96	11.6619
97	94 09	9.8489	137	1 87 69	11.7047
98	96 04	9.8995	138	1 90 44	11.7473
99	98 01	9.9499	139	1 93 21	11.7898
100	1 00 00	10.0000	140	1 96 00	11.8322
101	1 02 01	10.0499	141	1 98 81	11.8743
102	1 04 04	10.0995	142	2 01 64	11.9164
103	1 06 09	10.1489	143	2 04 49	11.9583
104	1 08 16	10.1980	144	2 07 36	12.0000
105	1 10 25	10.2470	145	2 10 25	12.0416
106	1 12 36	10.2956	146	2 13 16	12.0830
107	1 14 49	10.3441	147	2 16 09	12.1244
108	1 16 64	10.3923	148	2 19 04	12.1655
109	1 18 81	10.4403	149	2 22 01	12.2066
110	1 21 00	10.4881	150	2 25 00	12.2474
111	1 23 21	10.5357	151	2 28 01	12.2882
112	1 25 44	10.5830	152	2 31 04	12.3288
113	1 27 69	10.6301	153	2 34 09	12.3693
114	1 29 96	10.6771	154	2 37 16	12.4097
115	1 32 25	10.7238	155	2 40 25	12.4499
116	1 34 56	10.7703	156	2 43 36	12.4900
117	1 36 89	10.8167	157	2 46 49	12.5300
118	1 39 24	10.8628	158	2 49 64	12.5698
119	1 41 61	10.9087	159	2 52 81	12.6095
120	1 44 00	10.9545	160	2 56 00	12.6491

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Number	Square	Square root	Number	Square	Square root
161	2 59 21	12.6886	201	4 04 01	14.1774
162	2 62 44	12.7279	202	4 08 04	14.2127
163	2 65 69	12.7671	203	4 12 09	14.2478
164	2 68 96	12.8062	204	4 16 16	14.2829
165	2 72 25	12.8452	205	4 20 25	14.3178
166	2 75 56	12.8841	206	4 24 36	14.3527
167	2 78 89	12.9228	207	4 28 49	14.3875
168	2 82 24	12.9615	208	4 32 64	14.4222
169	2 85 61	13.0000	209	4 36 81	14.4568
170	2 89 00	13.0384	210	4 41 00	14.4914
171	2 92 41	13.0767	211	4 45 21	14.5258
172	2 95 84	13.1149	212	4 49 44	14.5602
173	2 99 29	13.1529	213	4 53 69	14.5945
174	3 02 76	13.1909	214	4 57 96	14.6287
175	3 06 25	13.2288	215	4 62 25	14.6629
176	3 09 76	13.2665	216	4 66 56	14.6969
177	3 13 29	13.3041	217	4 70 89	14.7309
178	3 16 84	13.3417	218	4 75 24	14.7648
179	3 20 41	13.3791	219	4 79 61	14.7986
180	3 24 00	13.4164	220	4 84 00	14.8324
181	3 27 61	13.4536	221	4 88 41	14.8661
182	3 31 24	13.4907	222	4 92 84	14.8997
183	3 34 89	13.5277	223	4 97 29	14.9332
184	3 38 56	13.5647	224	5 01 76	14.9666
185	3 42 25	13.6015	225	5 06 25	15.0000
186	3 45 96	13.6382	226	5 10 76	15.0333
187	3 49 69	13.6748	227	5 15 29	15.0665
188	3 53 44	13.7113	228	5 19 84	15.0997
189	3 57 21	13.7477	229	5 24 41	15.1327
190	3 61 00	13.7840	230	5 29 00	15.1658
191	3 64 81	13.8203	231	5 33 61	15.1987
192	3 68 64	13.8564	232	5 38 24	15.2315
193	3 72 49	13.8924	233	5 42 89	15.2643
194	3 76 36	13.9284	234	5 47 56	15.2971
195	3 80 25	13.9642	235	5 52 25	15.3297
196	3 84 16	14.0000	236	5 56 96	15.3623
197	3 88 09	14.0357	237	5 61 69	15.3948
198	3 92 04	14.0712	238	5 66 44	15.4272
199	3 96 01	14.1067	239	5 71 21	15.4596
200	4 00 00	14.1421	240	5 76 00	15.4919

Number	Square	Square root	Number	Square	Square root
241	5 80 81	15.5242	281	7 89 61	16.7631
242	5 85 64	15.5563	282	7 95 24	16.7929
243	5 90 49	15.5885	283	8 00 89	16.8226
244	5 95 36	15.6205	284	8 06 56	16.8523
245	6 00 25	15.6525	285	8 12 25	16.8819
246	6 05 16	15.6844	286	8 17 96	16.9115
247	6 10 09	15.7162	287	8 23 69	16.9411
248	6 15 04	15.7480	288	8 29 44	16.9706
249	6 20 01	15.7797	289	8 35 21	17.0000
250	6 25 00	15.8114	290	8 41 00	17.0294
251	6 30 01	15.8430	291	8 46 81	17.0587
252	6 35 04	15.8745	292	8 52 64	17.0880
253	6 40 09	15.9060	293	8 58 49	17.1172
254	6 45 16	15.9374	294	8 64 36	17.1464
255	6 50 25	15.9687	295	8 70 25	17.1756
256	6 55 36	16.0000	296	8 76 16	17.2047
257	6 60 49	16.0312	297	8 82 09	17.2337
258	6 65 64	16.0624	298	8 88 04	17.2627
259	6 70 81	16.0935	299	8 94 01	17.2916
260	6 76 00	16.1245	300	9 00 00	17.3205
261	6 81 21	16.1555	301	9 06 01	17.3494
262	6 86 44	16.1864	302	9 12 04	17.3781
263	6 91 69	16.2173	303	9 18 09	17.4069
264	6 96 96	16.2481	304	9 24 16	17.4356
265	7 02 25	16.2788	305	9 30 25	17.4642
266	7 07 56	16.3095	306	9 36 36	17.4929
267	7 12 89	16.3401	307	9 42 49	17.5214
268	7 18 24	16.3707	308	9 48 64	17.5499
269	7 23 61	16.4012	309	9 54 81	17.5784
270	7 29 00	16.4317	310	9 61 00	17.6068
271	7 34 41	16.4621	311	9 67 21	17.6352
272	7 39 84	16.4924	312	9 73 44	17.6635
273	7 45 29	16.5227	313	9 79 69	17.6918
274	7 50 76	16.5529	314	9 85 96	17.7200
275	7 56 25	16.5831	315	9 92 25	17.7482
276	7 61 76	16.6132	316	9 98 56	17.7764
277	7 67 29	16.6433	317	10 04 89	17.8045
278	7 72 84	16.6733	318	10 11 24	17.8326
279	7 78 41	16.7033	319	10 17 61	17.8606
280	7 84 00	16.7332	320	10 24 00	17.8885

Number	Square	Square root	Number	Square	Square root
321	10 30 41	17.9165	361	13 03 21	19.0000
322	10 36 84	17.9444	362	13 10 44	19.0263
323	10 43 29	17.9722	363	13 17 69	19.0526
324	10 49 76	18.0000	364	13 24 96	19.0788
325	10 56 25	18.0278	365	13 32 25	19.1050
326	10 62 76	18.0555	366	13 39 56	19.1311
327	10 69 29	18.0831	367	13 46 89	19.1572
328	10 75 84	18.1108	368	13 54 24	19.1833
329	10 82 41	18.1384	369	13 61 61	19.2094
330	10 89 00	18.1659	370	13 69 00	19.2354
331	10 95 61	18.1934	371	13 76 41	19.2614
332	11 02 24	18.2209	372	13 83 84	19.2873
333	11 08 89	18.2483	373	13 91 29	19.3132
334	11 15 56	18.2757	374	13 98 76	19.3391
335	11 22 25	18.3030	375	14 06 25	19.3649
336	11 28 96	18.3303	376	14 13 76	19.3907
337	11 35 69	18.3576	377	14 21 29	19.4165
338	11 42 44	18.3848	378	14 28 84	19.4422
339	11 49 21	18.4120	379	14 36 41	19.4679
340	11 56 00	18.4391	380	14 44 00	19.4936
341	11 62 81	18.4662	381	14 51 61	19.5192
342	11 69 64	18.4932	382	14 59 24	19.5448
343	11 76 49	18.5203	383	14 66 89	19.5704
344	11 83 36	18.5472	384	14 74 56	19.5959
345	11 90 25	18.5742	385	14 82 25	19.6214
346	11 97 16	18.6011	386	14 89 96	19.6469
347	12 04 09	18.6279	387	14 97 69	19.6723
348	12 11 04	18.6548	388	[illegible] 05 44	19.6977
349	12 18 01	18.6815	389	[illegible] 13 21	19.7231
350	12 25 00	18.7083	390	15 21 00	19.7484
351	12 32 01	18.7350	391	15 28 81	19.7737
352	12 39 04	18.7617	392	15 36 64	19.7990
353	12 46 09	18.7883	393	15 44 49	19.8242
354	12 53 16	18.8149	394	15 52 36	19.8494
355	12 60 25	18.8414	395	15 60 25	19.8746
356	12 67 36	18.8680	396	15 68 16	19.8997
357	12 74 49	18.8944	397	15 76 09	19.9249
358	12 81 64	18.9209	398	15 84 04	19.9499
359	12 88 81	18.9473	399	15 92 01	19.9750
360	12 96 00	18.9737	400	16 00 00	20.0000

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Number	Square	Square root	Number	Square	Square root
401	16 08 01	20.0250	441	19 44 81	21.0000
402	16 16 04	20.0499	442	19 53 64	21.0238
403	16 24 09	20.0749	443	19 62 49	21.0476
404	16 32 16	20.0998	444	19 71 36	21.0713
405	16 40 25	20.1246	445	19 80 25	21.0950
406	16 48 36	20.1494	446	19 89 16	21.1187
407	16 56 49	20.1742	447	19 98 09	21.1424
408	16 64 64	20.1990	448	20 07 04	21.1660
409	16 72 81	20.2237	449	20 16 01	21.1896
410	16 81 00	20.2485	450	20 25 00	21.2132
411	16 89 21	20.2731	451	20 34 01	21.2368
412	16 97 44	20.2978	452	20 43 04	21.2603
413	17 05 69	20.3224	453	20 52 09	21.2838
414	17 13 96	20.3470	454	20 61 16	21.3073
415	17 22 25	20.3715	455	20 70 25	21.3307
416	17 30 56	20.3961	456	20 79 36	21.3542
417	17 38 89	20.4206	457	20 88 49	21.3776
418	17 47 24	20.4450	458	20 97 64	21.4009
419	17 55 61	20.4695	459	21 06 81	21.4243
420	17 64 00	20.4939	460	21 16 00	21.4476
421	17 72 41	20.5183	461	21 25 21	21.4709
422	17 80 84	20.5426	462	21 34 44	21.4942
423	17 89 29	20.5670	463	21 43 69	21.5174
424	17 97 76	20.5913	464	21 52 96	21.5407
425	18 06 25	20.6155	465	21 62 25	21.5639
426	18 14 76	20.6398	466	21 71 56	21.5870
427	18 23 29	20.6640	467	21 80 89	21.6102
428	18 31 84	20.6882	468	21 90 24	21.6333
429	18 40 41	20.7123	469	21 99 61	21.6564
430	18 49 00	20.7364	470	22 09 00	21.6795
431	18 57 61	20.7605	471	22 18 41	21.7025
432	18 66 24	20.7846	472	22 27 84	21.7256
433	18 74 89	20.8087	473	22 37 29	21.7486
434	18 83 56	20.8327	474	22 46 76	21.7715
435	18 92 25	20.8567	475	22 56 25	21.7945
436	19 00 96	20.8806	476	22 65 76	21.8174
437	19 09 69	20.9045	477	22 75 29	21.8403
438	19 18 44	20.9284	478	22 84 84	21.8632
439	19 27 21	20.9523	479	22 94 41	21.8861
440	19 36 00	20.9762	480	23 04 00	21.9089

Number	Square	Square root	Number	Square	Square root
481	23 13 61	21.9317	521	27 14 41	22.8254
482	23 23 24	21.9545	522	27 24 84	22.8473
483	23 32 89	21.9773	523	27 35 29	22.8692
484	23 42 56	22.0000	524	27 45 76	22.8910
485	23 52 25	22.0227	525	27 56 25	22.9129
486	23 61 96	22.0454	526	27 66 76	22.9347
487	23 71 69	22.0681	527	27 77 29	22.9565
488	23 81 44	22.0907	528	27 87 84	22.9783
489	23 91 21	22.1133	529	27 98 41	23.0000
490	24 01 00	22.1359	530	28 09 00	23.0217
491	24 10 81	22.1585	531	28 19 61	23.0434
492	24 20 64	22.1811	532	28 30 24	23.0651
493	24 30 49	22.2036	533	28 40 89	23.0868
494	24 40 36	22.2261	534	28 51 56	23.1084
495	24 50 25	22.2486	535	28 62 25	23.1301
496	24 60 16	22.2711	536	28 72 96	23.1517
497	24 70 09	22.2935	537	28 83 69	23.1733
498	24 80 04	22.3159	538	28 94 44	23.1948
499	24 90 01	22.3383	539	29 05 21	23.2164
500	25 00 00	22.3607	540	29 16 00	23.2379
501	25 10 01	22.3830	541	29 26 81	23.2594
502	25 20 04	22.4054	542	29 37 64	23.2809
503	25 30 09	22.4277	543	29 48 49	23.3024
504	25 40 16	22.4499	544	29 59 36	23.3238
505	25 50 25	22.4722	545	29 70 25	23.3452
506	25 60 36	22.4944	546	29 81 16	23.3666
507	25 70 49	22.5167	547	29 92 09	23.3880
508	25 80 64	22.5389	548	30 03 04	23.4094
509	25 90 81	22.5610	549	30 14 01	23.4307
510	26 01 00	22.5832	550	30 25 00	23.4521
511	26 11 21	22.6053	551	30 36 01	23.4734
512	26 21 44	22.6274	552	30 47 04	23.4947
513	26 31 69	22.6495	553	30 58 09	23.5160
514	26 41 96	22.6716	554	30 69 16	23.5372
515	26 52 25	22.6936	555	30 80 25	23.5584
516	26 62 56	22.7156	556	30 91 36	23.5797
517	26 72 89	22.7376	557	31 02 49	23.6008
518	26 83 24	22.7596	558	31 13 64	23.6220
519	26 93 61	22.7816	559	31 24 81	23.6432
520	27 04 00	22.8035	560	31 36 00	23.6643

Number	Square	Square root	Number	Square	Square root
561	31 47 21	23.6854	601	36 12 01	24.5153
562	31 58 44	23.7065	602	36 24 04	24.5357
563	31 69 69	23.7276	603	36 36 09	24.5561
564	31 80 96	23.7487	604	36 48 16	24.5764
565	31 92 25	23.7697	605	36 60 25	24.5967
566	32 03 56	23.7908	606	36 72 36	24.6171
567	32 14 89	23.8118	607	36 84 49	24.6374
568	32 26 24	23.8328	608	36 96 64	24.6577
569	32 37 61	23.8537	609	37 08 81	24.6779
570	32 49 00	23.8747	610	37 21 00	24.6982
571	32 60 41	23.8956	611	37 33 21	24.7184
572	32 71 84	23.9165	612	37 45 44	24.7385
573	32 83 29	23.9374	613	37 57 69	24.7588
574	32 94 76	23.9583	614	37 69 96	24.7790
575	33 06 25	23.9792	615	37 82 25	24.7992
576	33 17 76	24.0000	616	37 94 56	24.8193
577	33 29 29	24.0208	617	38 06 89	24.8395
578	33 40 84	24.0416	618	38 19 24	24.8596
579	33 52 41	24.0624	619	38 31 61	24.8797
580	33 64 00	24.0832	620	38 44 00	24.8998
581	33 75 61	24.1039	621	38 56 41	24.9199
582	33 87 24	24.1247	622	38 68 84	24.9399
583	33 98 89	24.1454	623	38 81 29	24.9600
584	34 10 56	24.1661	624	38 93 76	24.9800
585	34 22 25	24.1868	625	39 06 25	25.0000
586	34 33 96	24.2074	626	39 18 76	25.0200
587	34 45 69	24.2281	627	39 31 29	25.0400
588	34 57 44	24.2487	628	39 43 84	25.0599
589	34 69 21	24.2693	629	39 56 41	25.0799
590	34 81 00	24.2899	630	39 69 00	25.0998
591	34 92 81	24.3105	631	39 81 61	25.1197
592	35 04 64	24.3311	632	39 94 24	25.1396
593	35 16 49	24.3516	633	40 06 89	25.1595
594	35 28 36	24.3721	634	40 19 56	25.1794
595	35 40 25	24.3926	635	40 32 25	25.1992
596	35 52 16	24.4131	636	40 44 96	25.2190
597	35 64 09	24.4336	637	40 57 69	25.2389
598	35 76 04	24.4540	638	40 70 44	25.2587
599	35 88 01	24.4745	639	40 83 21	25.2784
600	36 00 00	24.4949	640	40 96 00	25.2982

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Number	Square	Square root	Number	Square	Square root
641	41 08 81	25.3180	681	46 37 61	26.0960
642	41 21 64	25.3377	682	46 51 24	26.1151
643	41 34 49	25.3574	683	46 64 89	26.1343
644	41 47 36	25.3772	684	46 78 56	26.1534
645	41 60 25	25.3969	685	46 92 25	26.1725
646	41 73 16	25.4165	686	47 05 96	26.1916
647	41 86 09	25.4362	687	47 19 69	26.2107
648	41 99 04	25.4558	688	47 33 44	26.2298
649	42 12 01	25.4755	689	47 47 21	26.2488
650	42 25 00	25.4951	690	47 61 00	26.2679
651	42 38 01	25.5147	691	47 74 81	26.2869
652	42 51 04	25.5343	692	47 88 64	26.3059
653	42 64 09	25.5539	693	48 02 49	26.3249
654	42 77 16	25.5734	694	48 16 36	26.3439
655	42 90 25	25.5930	695	48 30 25	26.3629
656	43 03 36	25.6125	696	48 44 16	26.3818
657	43 16 49	25.6320	697	48 58 09	26.4008
658	43 29 64	25.6515	698	48 72 04	26.4197
659	43 42 81	25.6710	699	48 86 01	26.4386
660	43 56 00	25.6905	700	49 00 00	26.4575
661	43 69 21	25.7099	701	49 14 01	26.4764
662	43 82 44	25.7294	702	49 28 04	26.4953
663	43 95 69	25.7488	703	49 42 09	26.5141
664	44 08 96	25.7682	704	49 56 16	26.5330
665	44 22 25	25.7876	705	49 70 25	26.5518
666	44 35 56	25.8070	706	49 84 36	26.5707
667	44 48 89	25.8263	707	49 98 49	26.5895
668	44 62 24	25.8457	708	50 12 64	26.6083
669	44 75 61	25.8650	709	50 26 81	26.6271
670	44 89 00	25.8844	710	50 41 00	26.6458
671	45 02 41	25.9037	711	50 55 21	26.6646
672	45 15 84	25.9230	712	50 69 44	26.6833
673	45 29 29	25.9422	713	50 83 69	26.7021
674	45 42 76	25.9615	714	50 97 96	26.7208
675	45 56 25	25.9808	715	51 12 25	26.7395
676	45 69 76	26.0000	716	51 26 56	26.7582
677	45 83 29	26.0192	717	51 40 89	26.7769
678	45 96 84	26.0384	718	51 55 24	26.7955
679	46 10 41	26.0576	719	51 69 61	26.8142
680	46 24 00	26.0768	720	51 84 00	26.8328

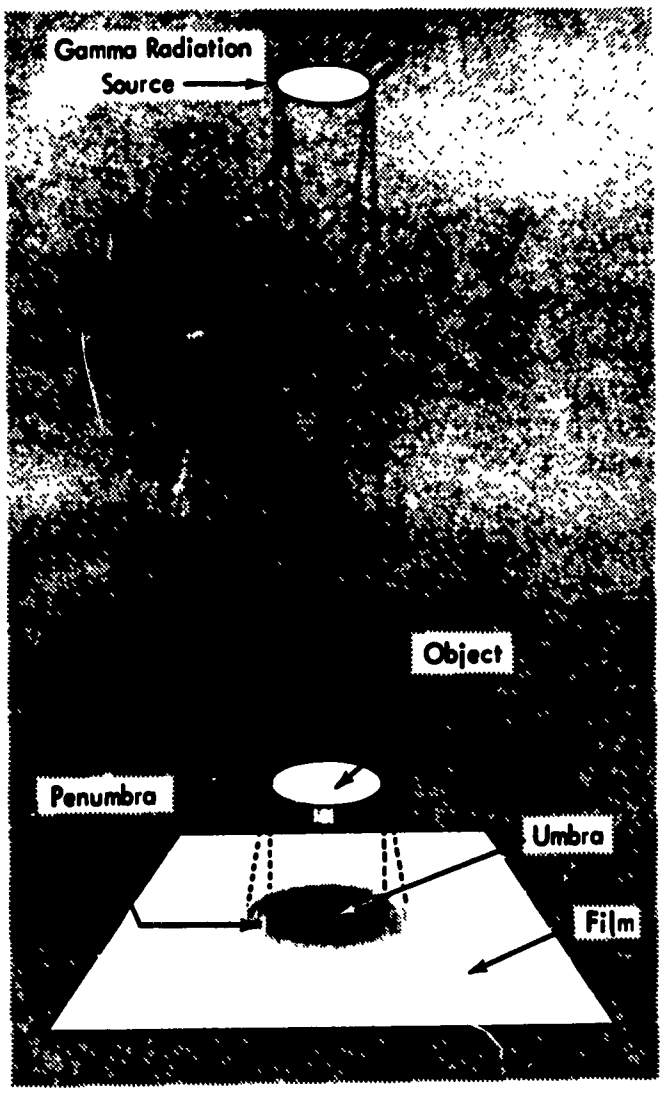
Number	Square	Square root	Number	Square	Square root
721	51 98 41	26.8514	761	57 91 21	27.5862
722	52 12 84	26.8701	762	58 06 44	27.6043
723	52 27 29	26.8887	763	58 21 69	27.6225
724	52 41 76	26.9072	764	58 36 96	27.6405
725	52 56 25	26.9258	765	58 52 25	27.6586
726	52 70 76	26.9444	766	58 67 56	27.6767
727	52 85 29	26.9629	767	58 82 89	27.6948
728	52 99 84	26.9815	768	58 98 24	27.7128
729	53 14 41	27.0000	769	59 13 61	27.7308
730	53 29 00	27.0185	770	59 29 00	27.7489
731	53 43 61	27.0370	771	59 44 41	27.7669
732	53 58 24	27.0555	772	59 59 84	27.7849
733	53 72 89	27.0740	773	59 75 29	27.8029
734	53 87 56	27.0924	774	59 90 76	27.8209
735	54 02 25	27.1109	775	60 06 25	27.8388
736	54 16 96	27.1293	776	60 21 76	27.8568
737	54 31 69	27.1477	777	60 37 29	27.8747
738	54 46 44	27.1662	778	60 52 84	27.8927
739	54 61 27	27.1846	779	60 68 41	27.9106
740	54 76 00	27.2029	780	60 84 00	27.9285
741	54 90 81	27.2213	781	60 99 61	27.9464
742	55 05 64	27.2397	782	61 15 24	27.9643
743	55 20 49	27.2580	783	61 30 89	27.9821
744	55 35 36	27.2764	784	61 46 56	28.0000
745	55 50 25	27.2947	785	61 62 25	28.0179
746	55 65 16	27.3130	786	61 77 96	28.0357
747	55 80 09	27.3313	787	61 93 69	28.0535
748	55 95 04	27.3496	788	62 09 44	28.0713
749	56 10 01	27.3679	789	62 25 21	28.0891
750	56 25 00	27.3861	790	62 41 00	28.1069
751	56 40 01	27.4044	791	62 56 81	28.1247
752	56 55 04	27.4226	792	62 72 64	28.1425
753	56 70 09	27.4408	793	62 88 49	28.1603
754	56 85 16	27.4591	794	63 04 36	28.1780
755	57 00 25	27.4773	795	63 20 25	28.1957
756	57 15 36	27.4955	796	63 36 16	28.2135
757	57 30 49	27.5136	797	63 52 09	28.2312
758	57 45 64	27.5318	798	63 68 04	28.2489
759	57 60 81	27.5500	799	63 84 01	28.2666
760	57 76 00	27.5681	800	64 00 00	28.2843

* By permission from H. Sorenson, *Statistics for students of psychology and education*, copyright 1936, McGraw-Hill Book Company, Inc., New York.

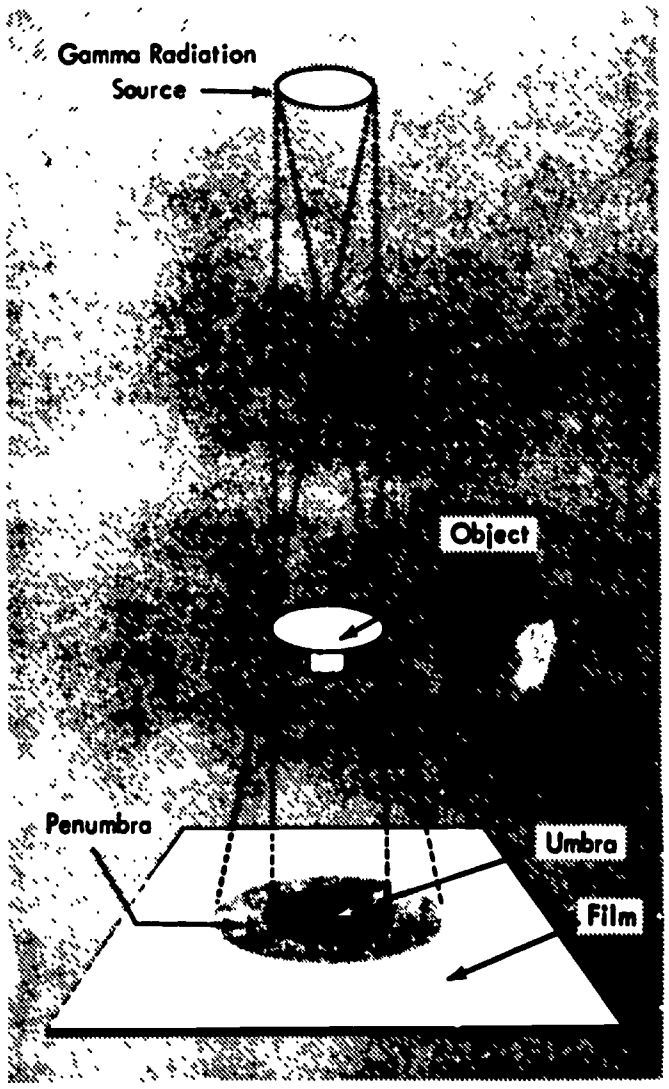
Information Sheet
on

EFFECT OF GEOMETRY ON SHADOW IMAGE

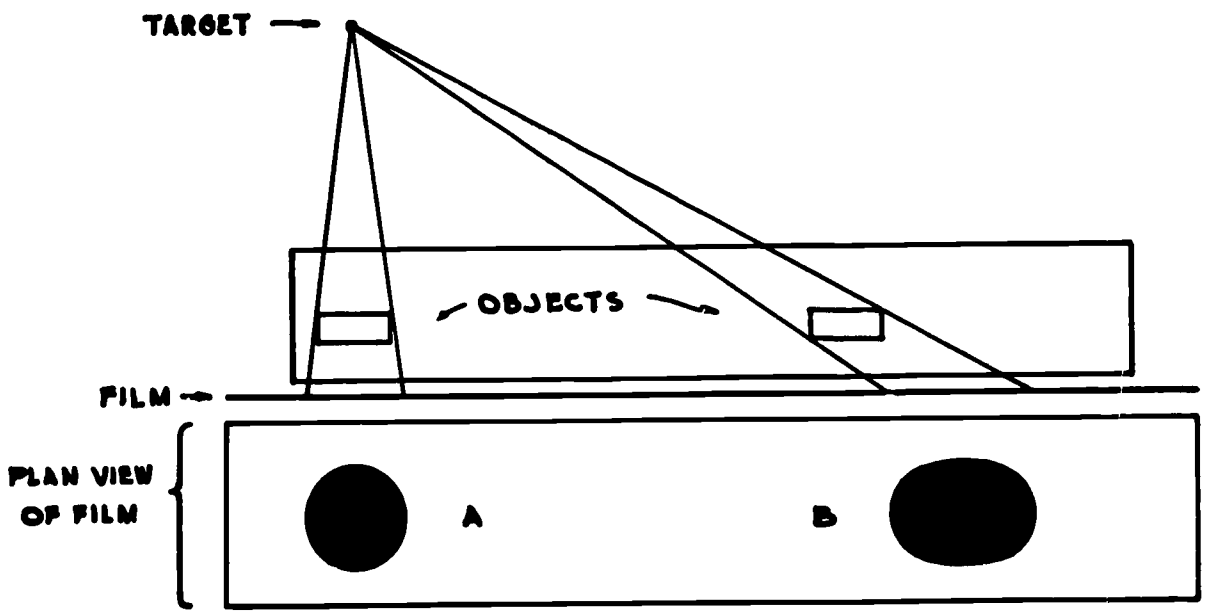
Information
Sheet # 6



REDUCING THE OBJECT-TO-FILM DISTANCE



INCREASING THE SOURCE-TO-FILM DISTANCE

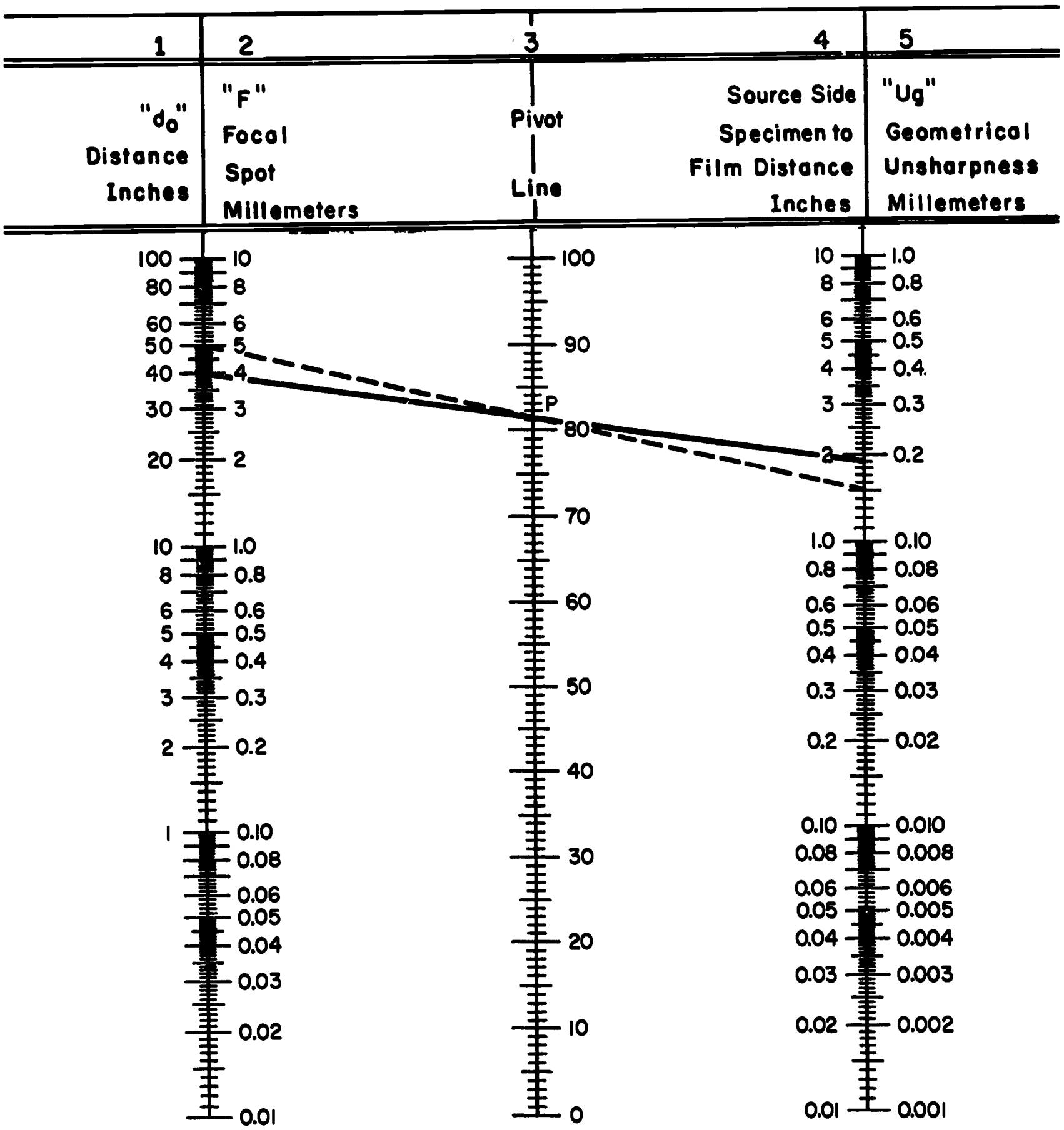


DISTORTION RESULTING FROM DIFFERENT FILM ANGLES

Information Sheet
on

NOMOGRAM FOR DETERMINING GEOMETRIC UNSHARPNESS

Information Sheet # 7



Courtesy of The Ronald Press Company (see Reference (4))

▲ Nomogram for Determining Geometric Unsharpness.

Note: 2 to 4 to find 3(Pivot); then 1 through 3(Pivot) to find 5.

Logarithmic method of determining half value and tenth value layers

$$N = \text{LOG} \frac{I_1}{I_2}$$

Where:
N= Number of TVL's
I_1 = Intensity of the incident radiation at a point
I_2= Intensity of the emergent radiation at the same point

$$M=3.3 \text{ LOG} \frac{I_1}{I_2}$$

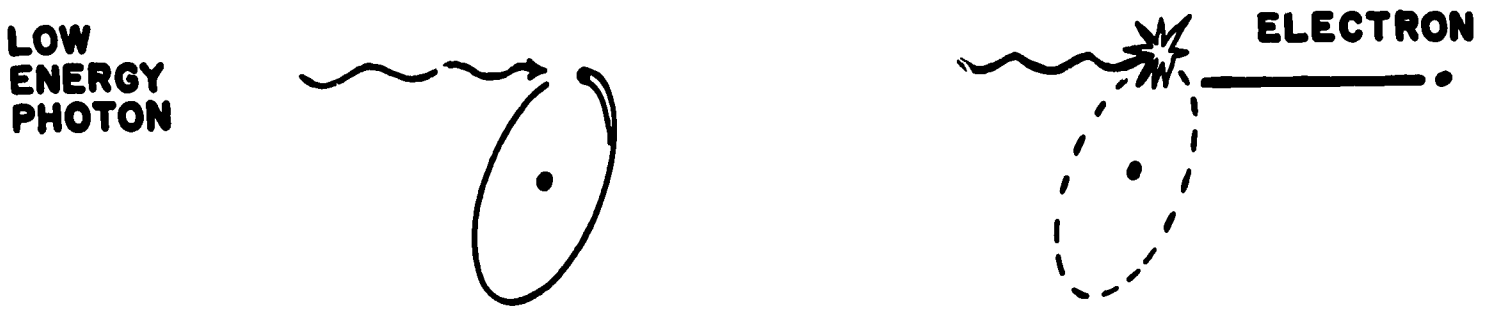
Where:
M= Number of half value layers

THREE-PLACE COMMON LOGARITHMS

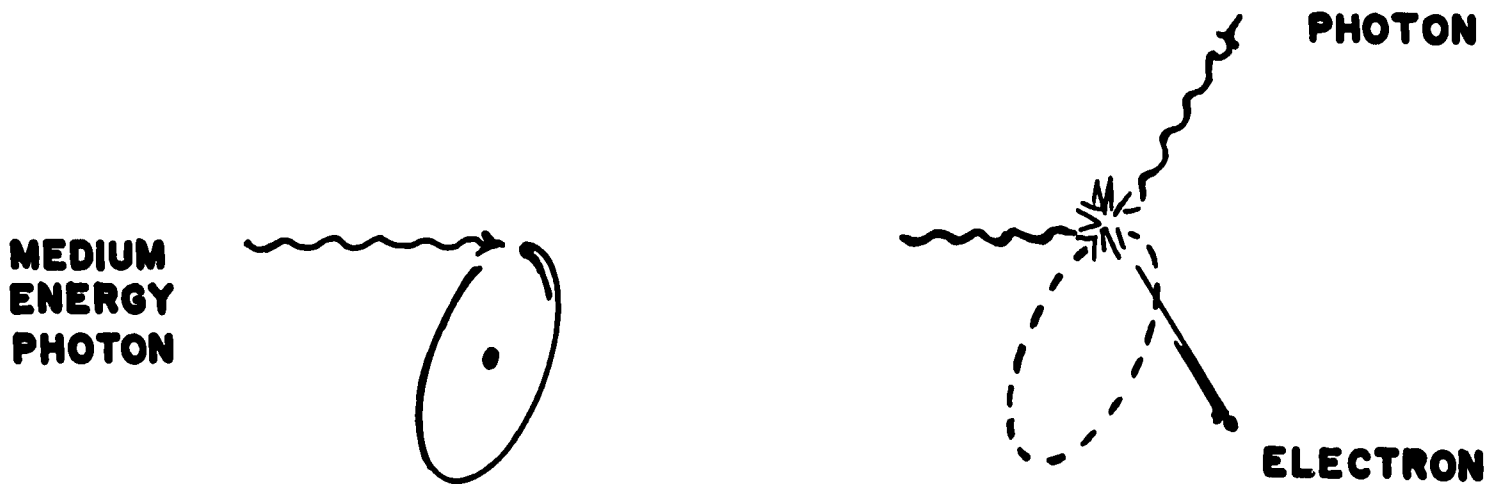
Number	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1.0	0.000	041	079	114	146	176	204	230	255	279
2.0	0.301	322	342	362	380	398	415	43:	447	462
3.0	0.477	491	505	519	532	544	556	568	580	591
4.0	0.602	613	623	634	644	653	663	672	681	690
5.0	0.699	708	716	724	732	740	748	756	763	771
6.0	0.778	785	792	799	806	813	820	826	833	839
7.0	0.845	851	857	863	869	875	881	887	892	898
8.0	0.903	909	914	919	924	929	935	940	945	949
9.0	0.954	959	964	969	973	978	982	987	991	996

Information Sheet
on
GAMMA RADIATION EFFECT
ON MATTER

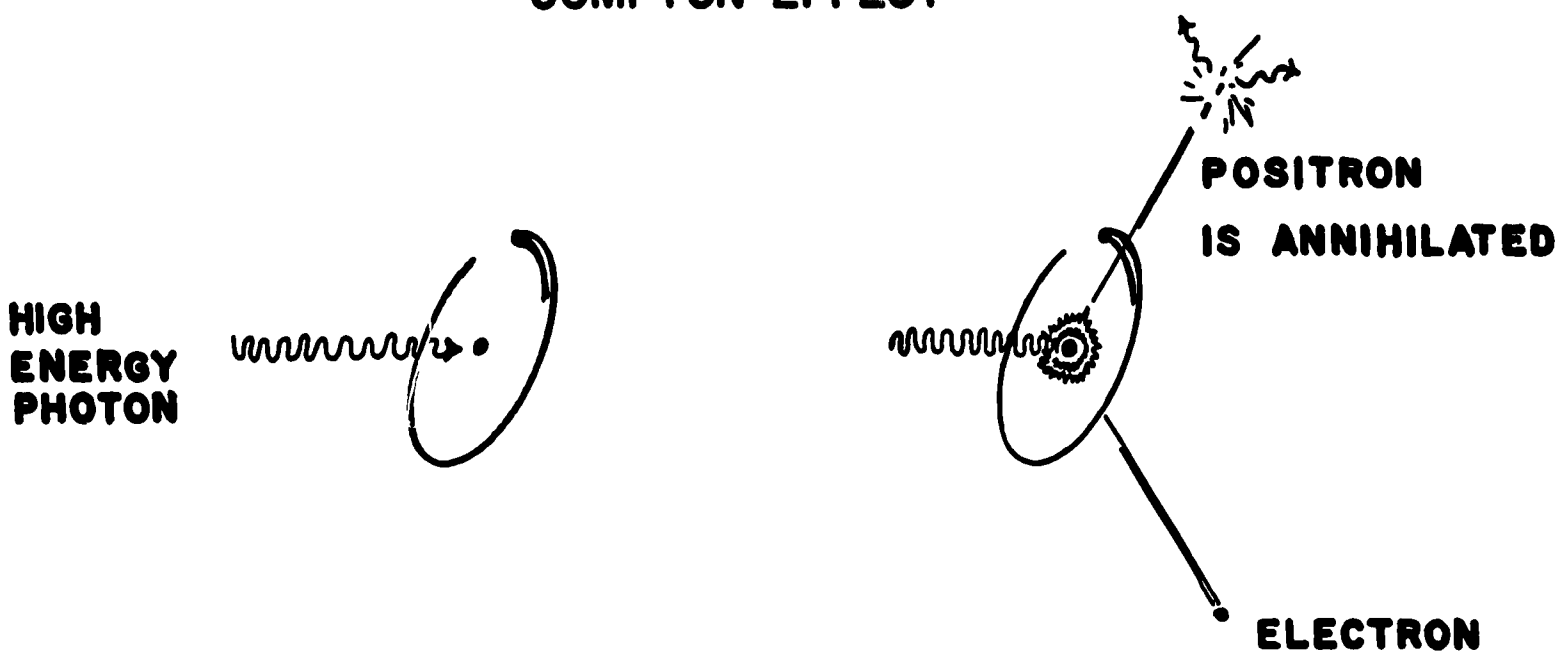
Information
Sheet # 9



PHOTOELECTRIC EFFECT



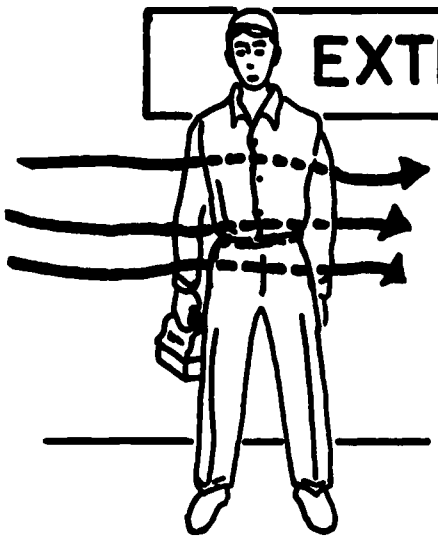
COMPTON EFFECT



PAIR PRODUCTION

Information Sheet
on
PHYSICAL RADIATION EFFECTS

Information
Sheet # 10



EXTERNAL RADIATION HAZARD

Some radiation goes through the body like X-rays, gamma rays and neutrons. (Beta particles to limited extent.)

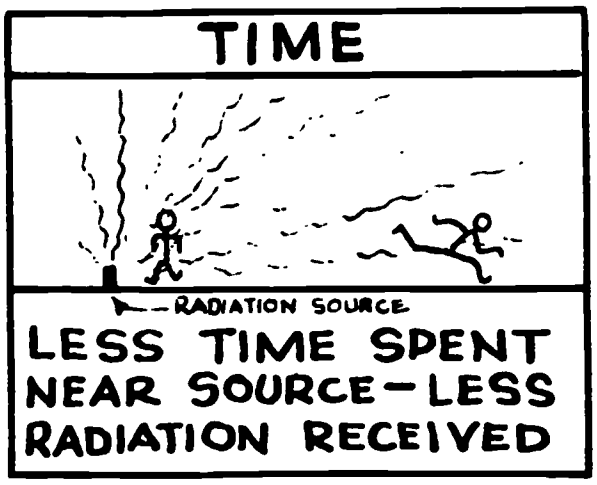
INTERNAL RADIATION HAZARD

We can receive radiation by swallowing or breathing radioactive materials. Includes alpha particles, beta particles and gamma ray emitter.

Information Sheet
on
RADIATION PROTECTION FACTORS

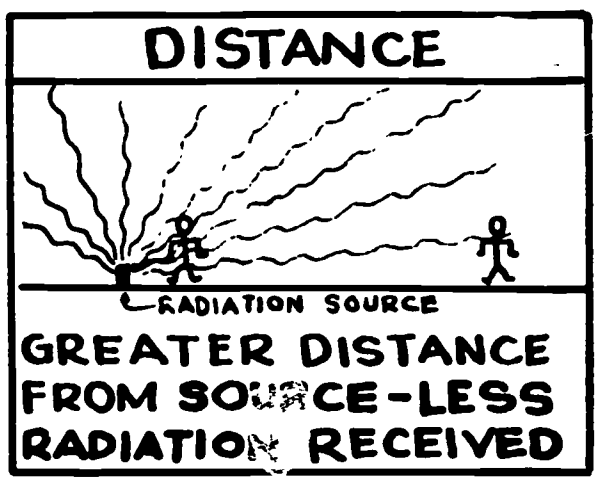
Information Sheet # 11

1.



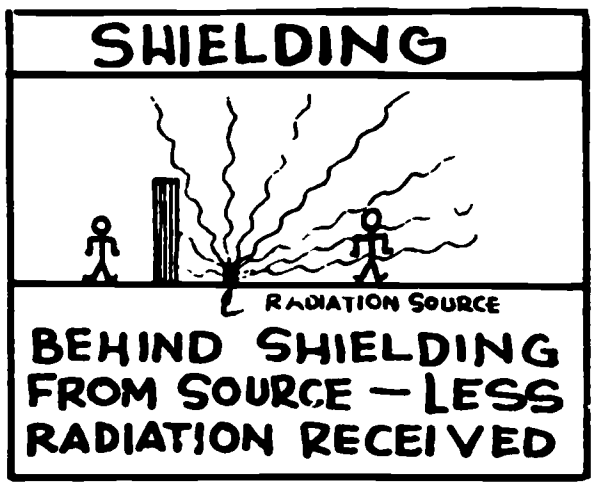
1. Radiation dose directly proportional to time

2.



2. Intensity of radiation is proportional to the inverse square law of the distance from the source

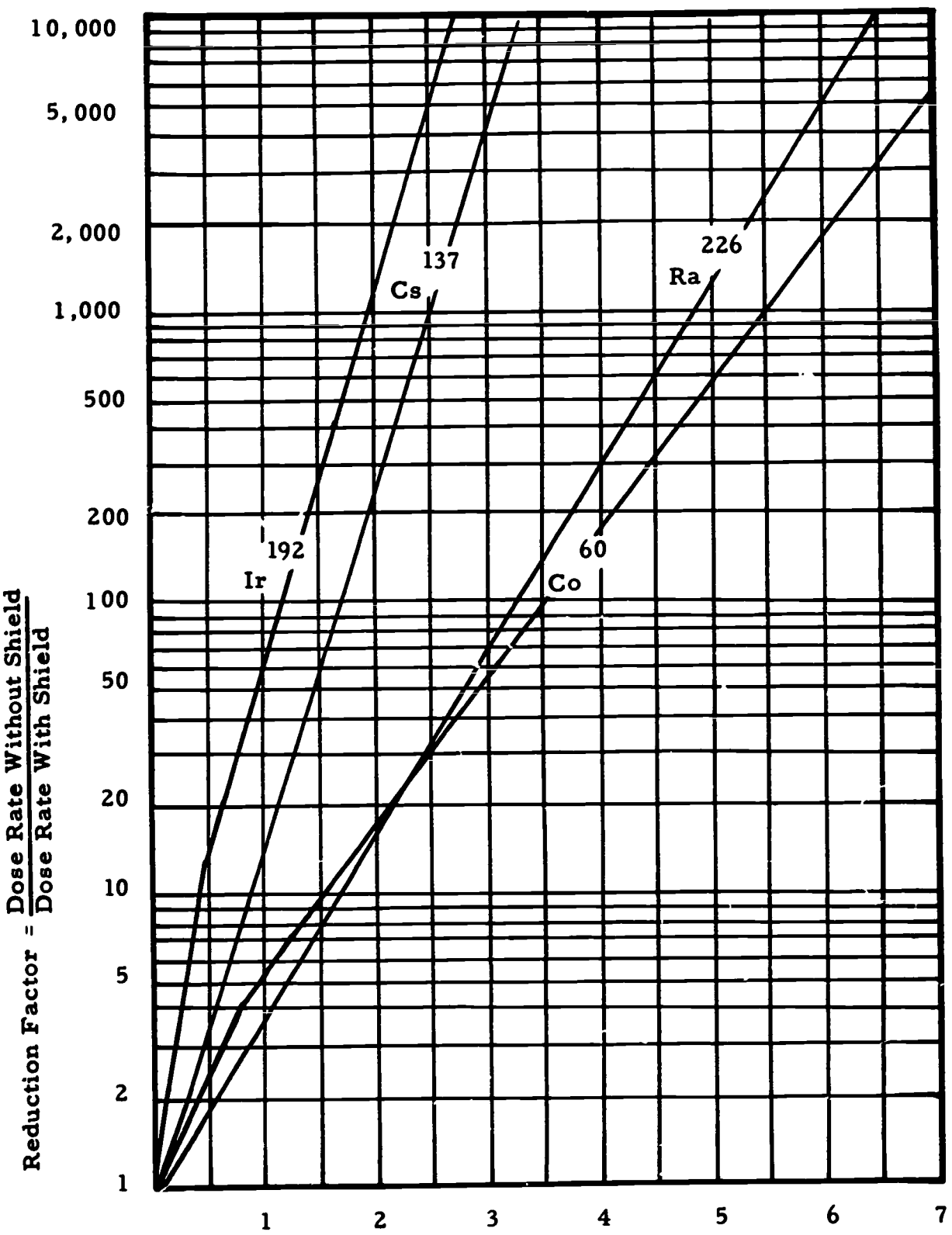
3.



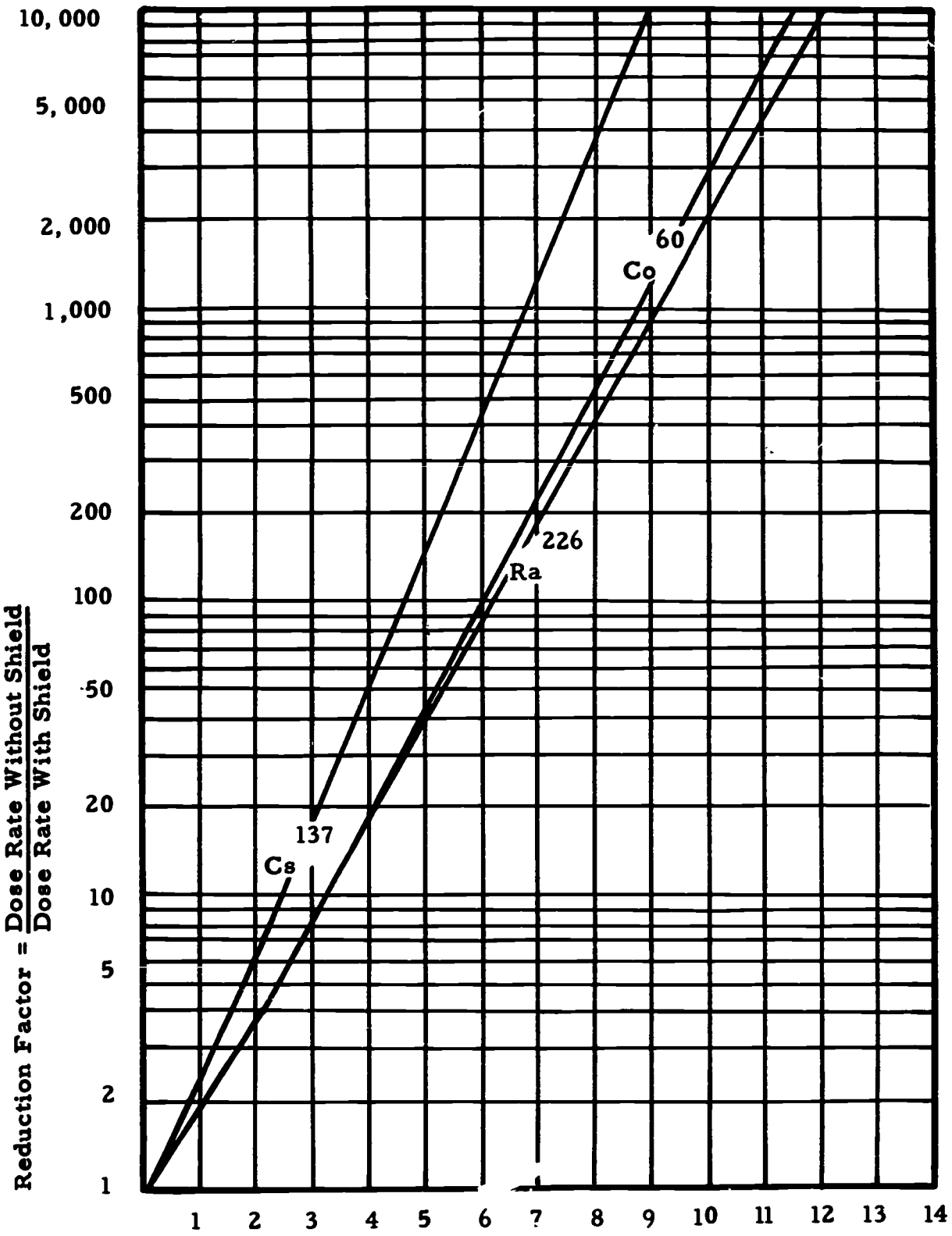
3. Density and thickness of the shielding material and the intensity and energy of the source are factors in radiation exposure

Information Sheet
on
SHIELDING CHARTS

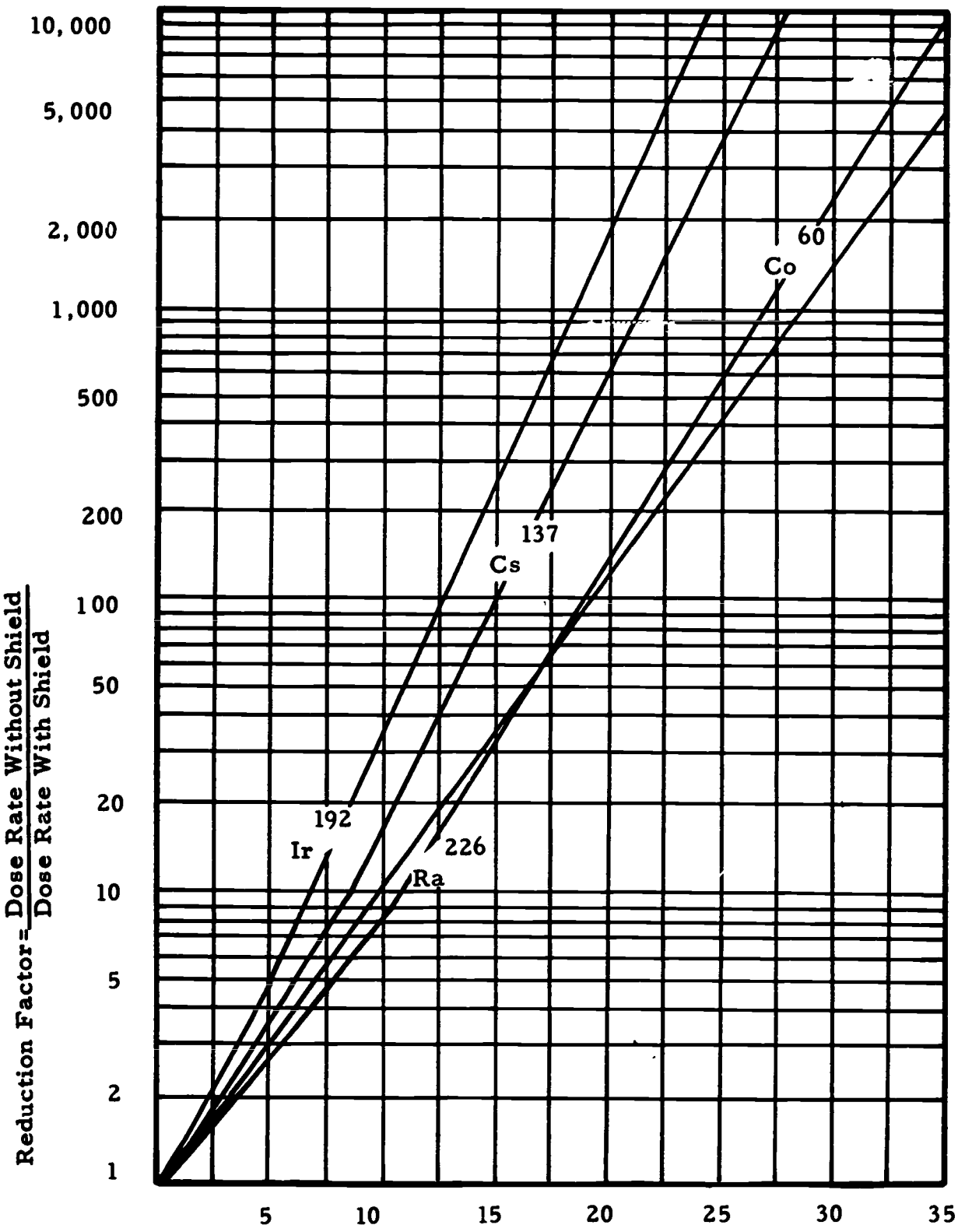
Information
Sheet # 12



BROADBEAM SHIELDING FOR ABSORPTION OF
192 137 60 226
Ir , Cs , Co , AND Ra
GAMMA RAYS IN LEAD



BROADBEAM SHIELDING FOR ABSORPTION OF
137 60 226
Cs , Co , Ra --GAMMA RAYS IN IRON



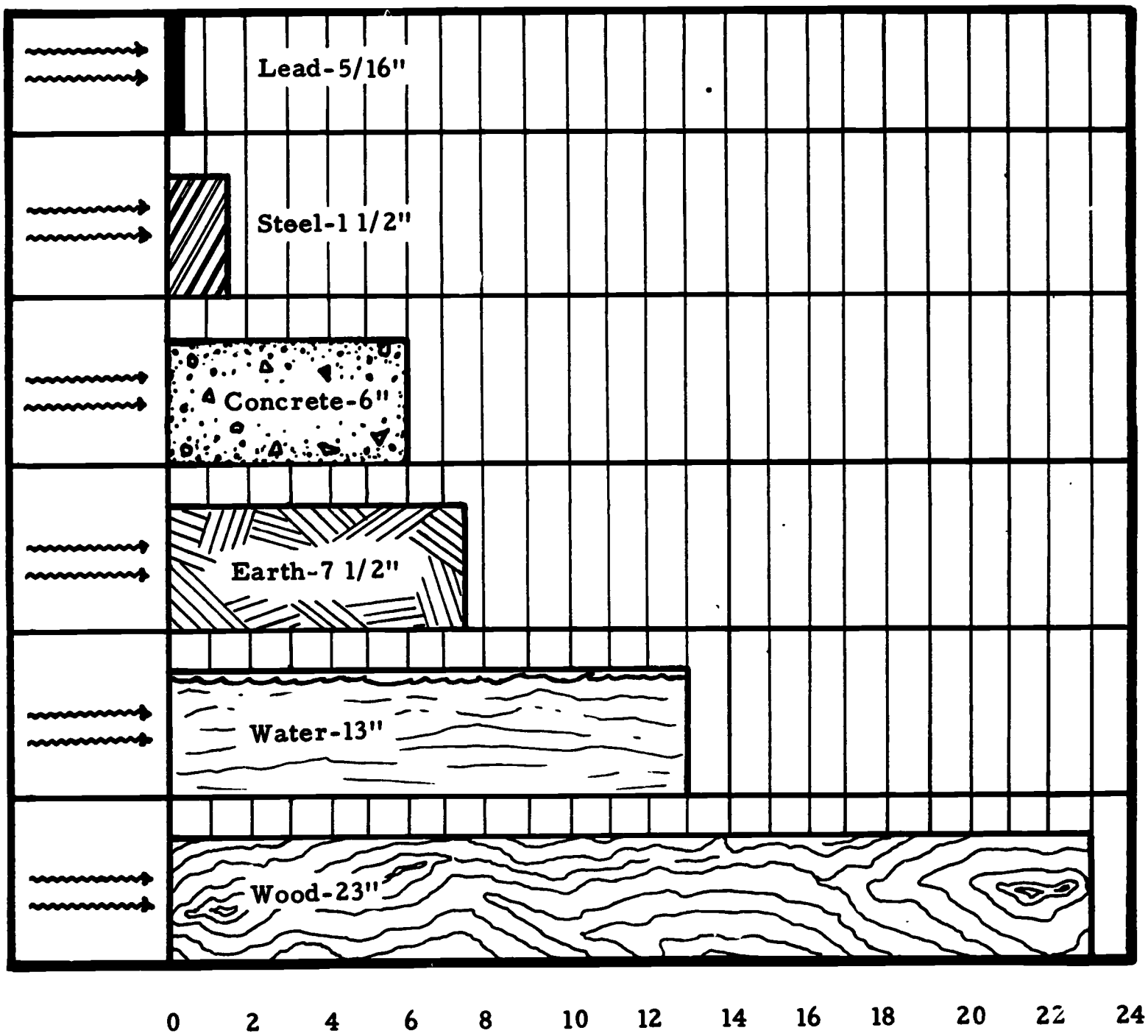
BROADBEAM SHIELDING FOR ABSORPTION OF
192 137 60 226
Ir , Cs , Co , AND Ra
GAMMA RAYS IN CONCRETE

Information Sheet
on

RELATIVE EFFECIENCY OF SHIELDING MATERIALS

Information
Sheet # 13

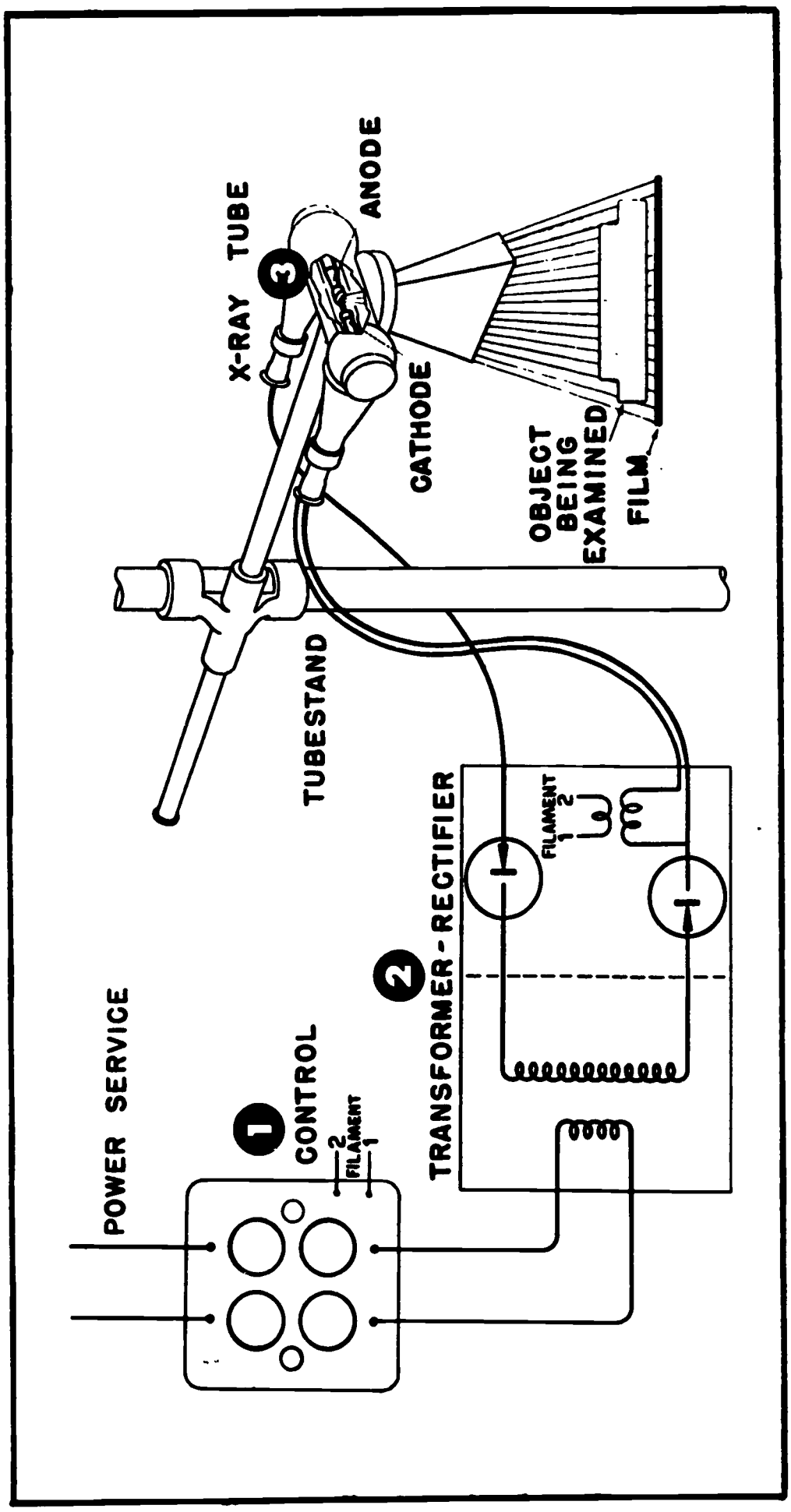
Relative thickness of materials required to absorb the same amount of gamma radiation having energy approximately 1 mev



RELATIVE EFFECIENCY OF SHIELDING MATERIALS

Information Sheet
on
X-RAY SCHEMATIC REPRESENTATION

Information
Sheet # 14



Information Sheet # 15

Information Sheet on GAMMA RAY DECAY TABLES

SOURCE STRENGTH CALIBRATION

To find source strength at any number of months after known source strength at calibration, multiply by the following percentages.

Months	0	1	2	3	4	5	6	7	8	9
0	--	98.9	97.8	96.8	95.7	94.7	93.6	92.6	91.6	90.6
10	89.6	88.6	87.7	86.7	85.8	84.8	83.9	83.0	82.1	81.2
20	80.3	79.4	78.6	77.7	76.9	76.0	75.2	74.4	73.6	72.8
30	72.0	71.2	70.4	69.7	68.0	68.1	67.4	66.7	65.9	65.2
40	64.5	63.8	63.1	62.4	61.7	61.1	60.4	59.7	59.1	58.4
50	57.8	57.2	56.5	55.9	55.3	54.7	54.1	53.5	53.0	52.4
60	51.8	51.2	50.7	50.1	49.6	49.1	48.5	48.0	47.5	46.9
70	46.4	45.9	45.4	44.9	44.4	44.0	43.5	43.0	42.5	42.1
80	41.6	41.2	40.7	40.2	39.8	39.4	39.0	38.5	38.1	37.7
90	37.3	36.9	36.5	36.1	35.7	35.3	34.9	34.5	34.2	33.8
100	33.4	33.1	32.7	32.3	32.0	31.6	31.3	31.0	30.6	30.3
110	30.0	29.6	29.3	29.0	28.7	28.4	28.0	27.7	27.4	27.1
120	26.8	26.6	26.3	26.0	25.7	25.4	25.1	24.9	24.6	24.3
130	24.1	23.8	23.5	23.3	23.0	22.8	22.5	22.3	22.0	21.8
140	21.6	21.3	21.1	20.9	20.6					

^{60}COBALT , HALF- LIFE 5.27 YEARS

The exposure time is multiplied by a coefficient to compensate for the age of Cobalt^{60} dated from its removal from the reactor. Consider the date of the source and increase the time accordingly.

Age in Months	Coefficient	Age in Months	Coefficient
6	1.07	66	1.51
12	1.13	72	1.54
18	1.18	78	1.57
24	1.23	84	1.60
30	1.28	90	1.62
36	1.32	96	1.65
42	1.37	102	1.68
48	1.41	108	1.69
54	1.45	114	1.71
60	1.48	120	1.73

192
IRIDIUM , HALF-LIFE 74. 27 DAYS

To find source strength at any number of months after known source strength at calibration multiply, by the above percentages. For example:
1. Given: 100, 000 millicuries. Required: activity after 20 months.
Solution. 100, 000 millicuries is 100 curies. . 32% is . 0032. Whence 100 x . 0032 equals . 32 curies, . 32 curies x 100 equals 320 millicuries.
2. Given: 100 curies. Required: source strength after 29 months. Read directly from table. Answer: . 02 curies.

Months	Percent	Months	Percent	Months	Percent
0	100. 0	10	5. 9	20	. 32
1	74. 5	11	4. 2	21	. 23
2	59. 4	12	3. 2	22	. 17
3	41. 5	13	2. 3	23	. 13
4	31. 5	14	1. 7	24	. 09
5	23. 3	15	1. 3	25	. 07
6	16. 5	16	. 88	26	. 06
7	13. 2	17	. 75	27	. 04
8	8. 8	18	. 59	28	. 03
9	7. 5	19	. 42	29	. 02

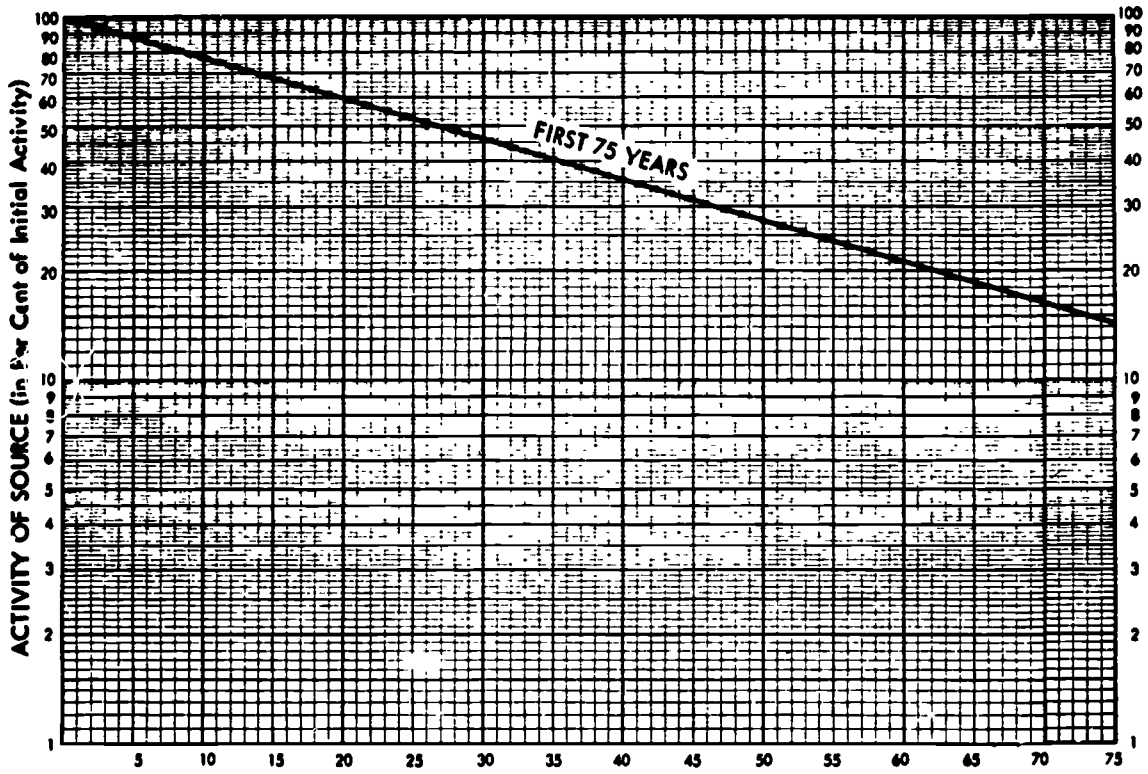
COMPARISON OF RADIATION FIELDS

Radiation field of one curie at different distances in milliroentgens per hour.

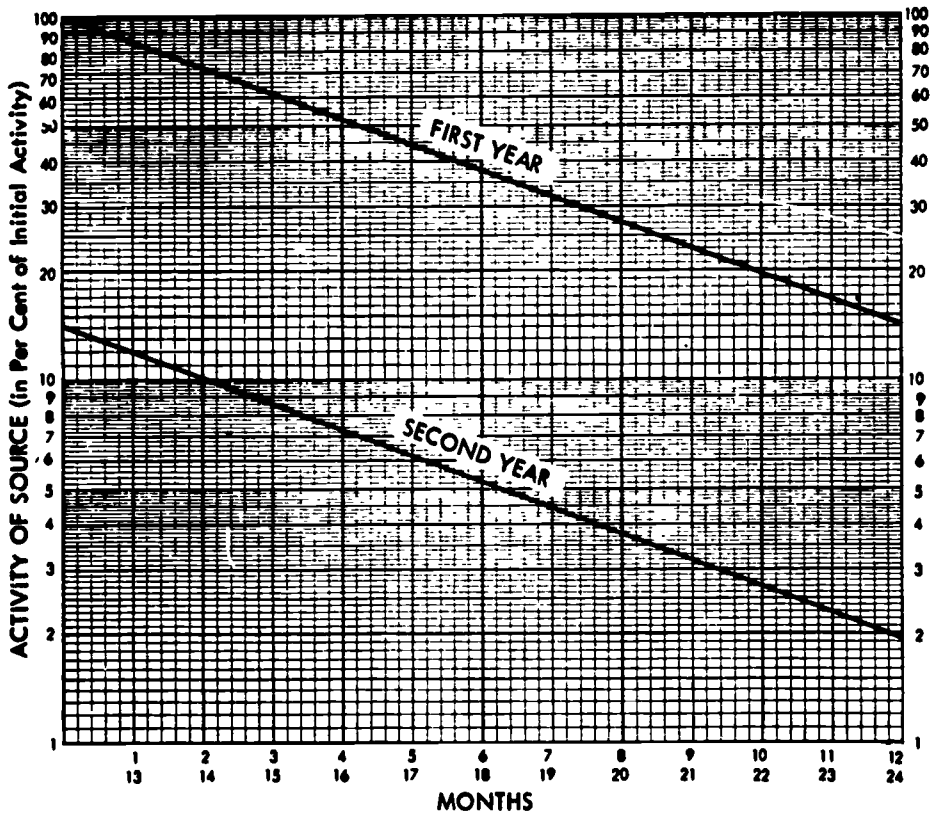
Source	1 ft.	2 ft.	4 ft.	8 ft.	16 ft.	32 ft.
^{192}Iridium	5900	1500	400	90	23	6
^{137}Cesium	4200	1100	260	70	16	4
^{60}Cobalt	14500	3600	900	230	60	14

Information Sheet
on
DECAY CHARTS
($COSIUM^{137}$ AND $THULIUM^{170}$)

Information Sheet # 16



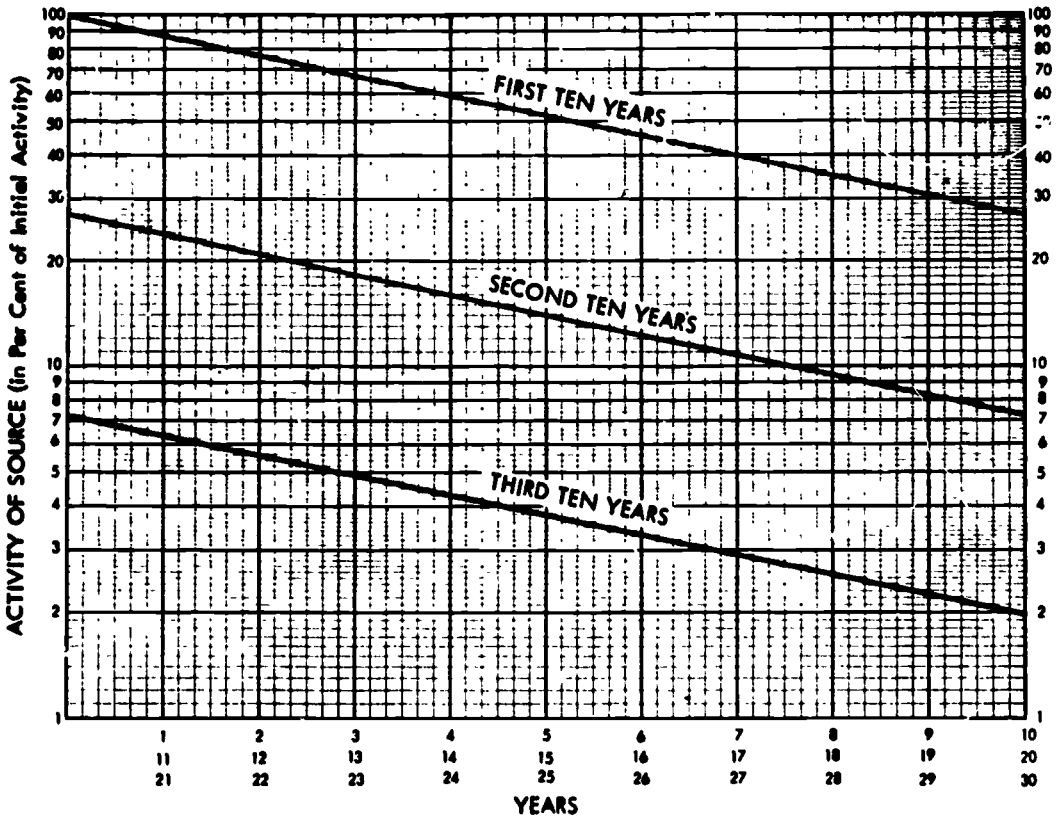
137
CESIUM DECAY



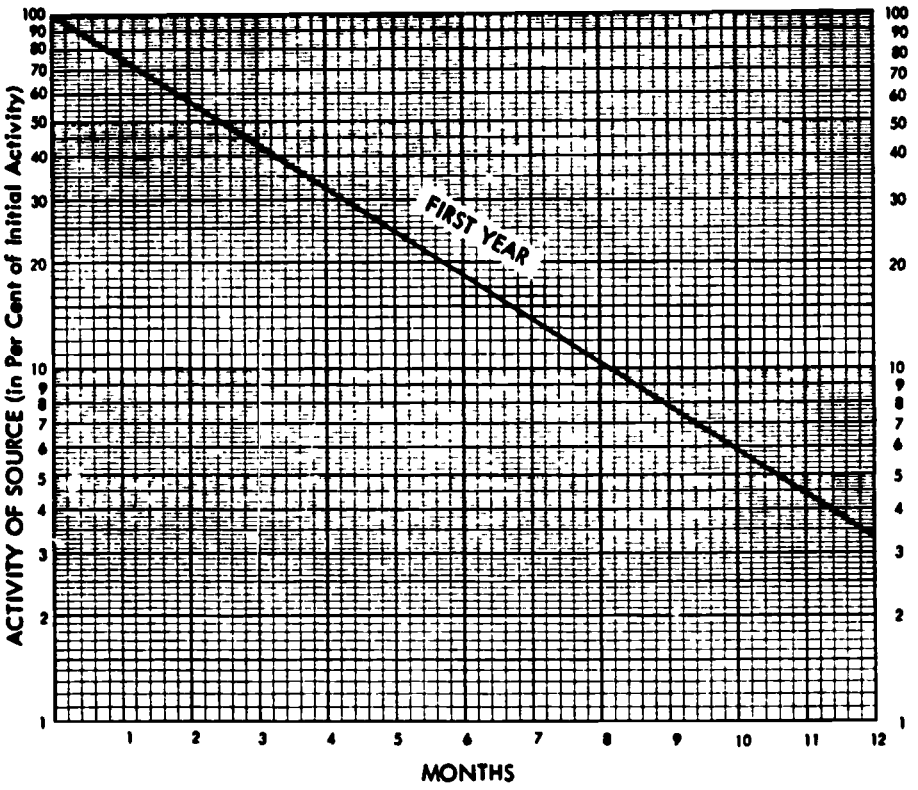
170
THULIUM DECAY

Information Sheet # 17

Information Sheet on DECAY CHARTS AND HALF-LIFE ($IRIDIUM^{192}$ AND $COBALT^{60}$)

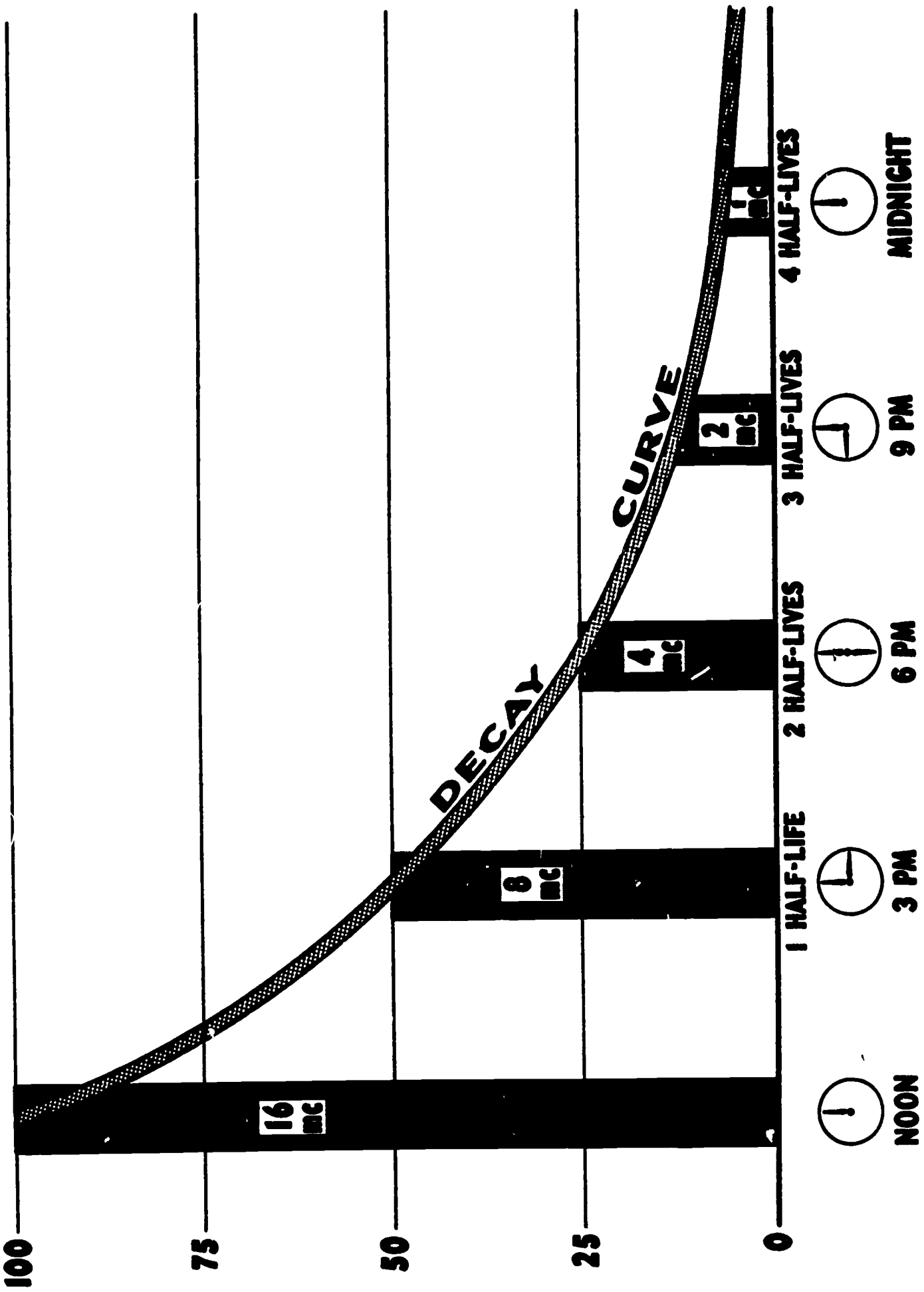


60
COBALT DECAY



192
IRIDIUM DECAY

THE MEANING OF HALF-LIFE



Information Sheet
on
METAL PROPERTIES

Information
Sheet # 18

Ductility- The property of being permanently extended by a tensile force

Elasticity- The capacity to return to the original dimensions after removal of the stress

Malleability- The property of being permanently extended or flattened by rolling or hammering

Toughness- The power to resist fracture when subjected to bending, torsional or impact forces

Brittleness- The tendency to fracture on receiving a shock

Hardness- The resistance to penetration

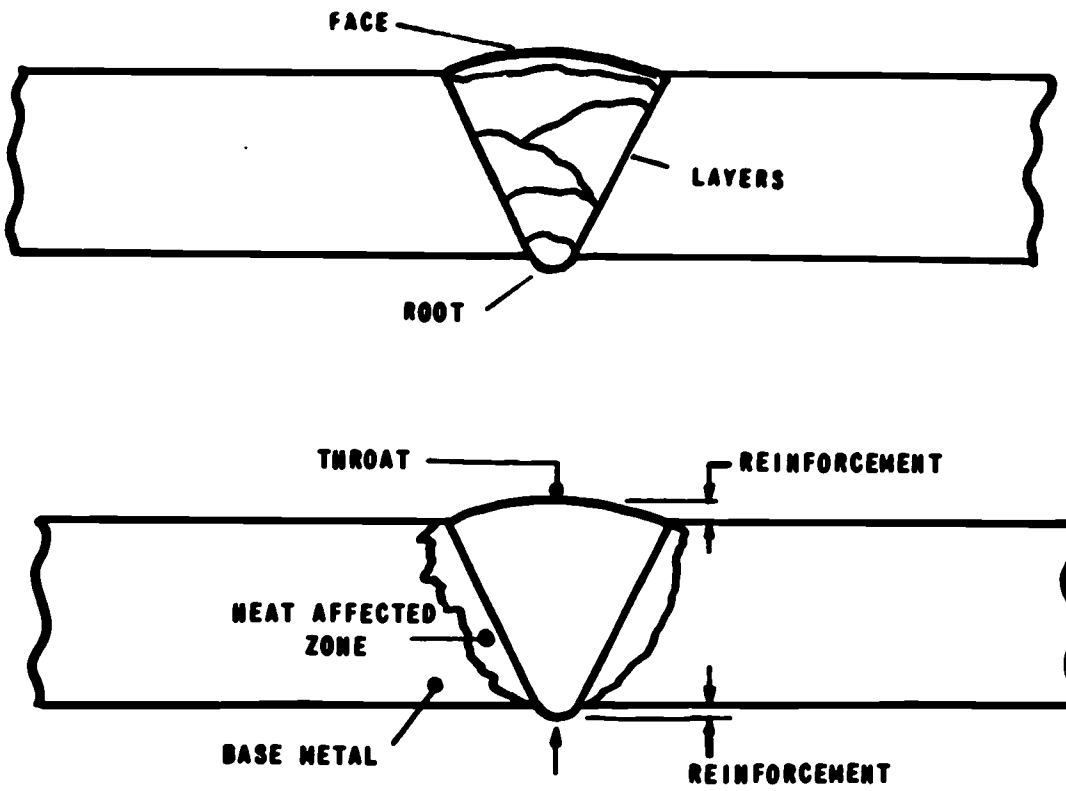
Conductivity- Ability to conduct heat or electricity

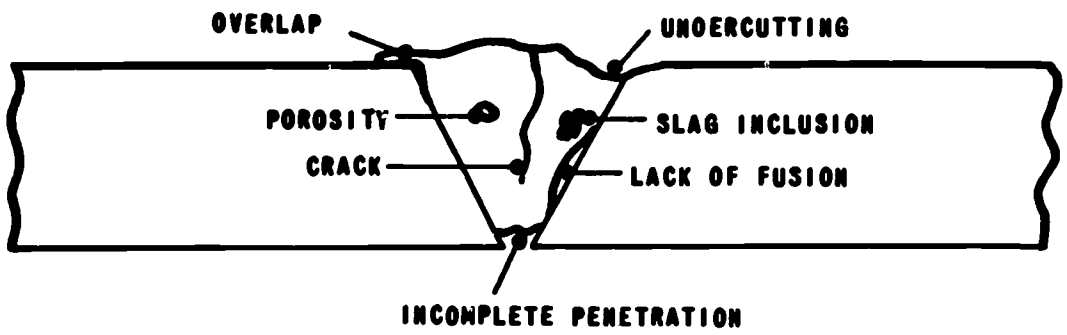
Dynamic fatigue- The gradual weakening of a material due to a cycle of stresses

Static fatigue- The gradual weakening due to a constant load

Information Sheet
on
WELD TERMINOLOGY

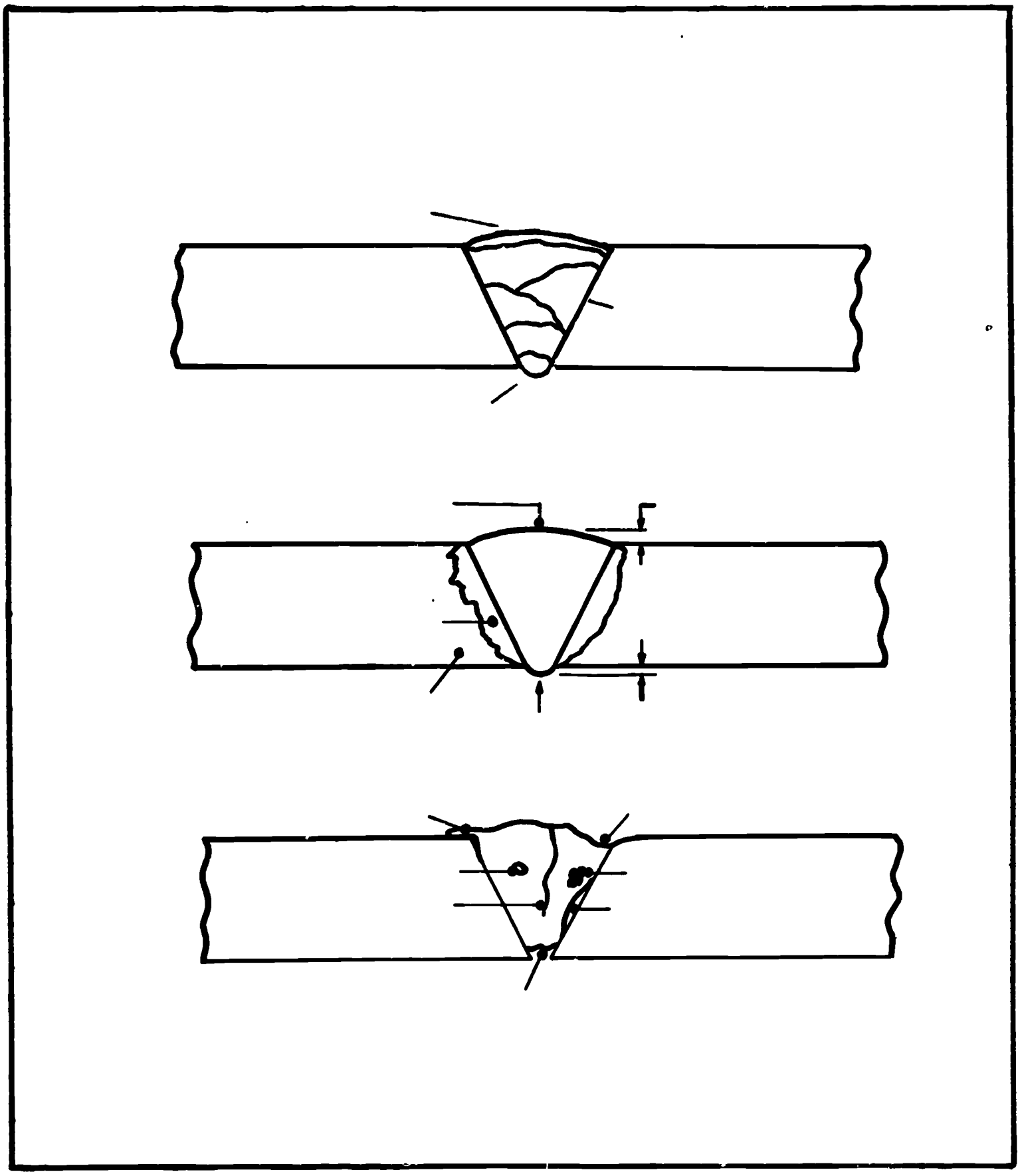
Information
Sheet #19





Information Sheet
on
WELD TERMINOLOGY
(TEST)

Information
Sheet # 20



Information Sheet
on
FIELD TRIP INSTRUCTION SHEET

Information
Sheet # 21

Students will sign the register provided, take a pair of safety glasses (unless your own glasses have safety lens), be assigned to a company guide, follow the guide's instructions and the company rules throughout the tour.

Safety consideration such as the following should be remembered:

1. Do not pickup any metal chips; they may be hot.
2. Do not touch parts in process or just removed(they are hot).
3. Do not look at arc welding.
4. Follow close to the guide at all times and do not go off the tour path; some areas are dangerous.
5. Be aware of moving vehicles, overhead cranes, conveyors, and material handling equipment.
6. Do not talk to operators or distract them from their jobs.
7. Listen to what your guide has to say and if you see a process that you do not understand, ask questions and take notes.
8. Wear your safety glasses at all times while in the plant.
9. Take note book and pencil.
10. Do not talk while guide is talking to group.

Information Sheet
on
STEEL PIPE AND THICKNESS TABLE

Information
Sheet # 22

A53 AND A106 PIPE

Pipe Size	O. D. In.	Sch 20	Sch 30	Sch [illegible]	Sch 60	Sch 80	Sch 100	Sch 120	Sch 140	Sch 160	XX Strong
. 50	. 84			. 109		. 147					. 294
. 75	1. 05			. 113		. 154					. 308
1. 00	1. 31			. 133		. 179					. 358
1. 25	1. 66			. 140		. 191					. 382
1. 50	1. 90			. 145		. 200					. 400
2. 00	2. 37			. 154		. 218					. 436
2. 50	2. 87			. 203		. 276					. 552
3. 00	3. 50			. 216		. 300					. 600
3. 50	4. 00			. 226		. 318					. 636
4. 00	4. 50			. 237		. 337		. 438			. 674
5. 00	5. 56			. 258		. 375		. 500			. 750
6. 00	6. 62			. 280		. 432		. 562			. 864
8. 00	8. 62		. 277	. 322	. 406	. 500	. 593	. 718			. 875
10. 00	10. 75		. 307	. 365	. 500	. 593	. 718	. 843			
12. 00	12. 75		. 330	. 406	. 560	. 687	. 843	1. 000			
14. 00		. 312	. 375	. 438	. 593	. 750	. 937	1. 090	1. 250	1. 40	
16. 00		. 312	. 375	. 500	. 656	. 843	1. 030	1. 210	1. 438	1. 59	
18. 00		. 312	. 438	. 563	. 750	. 937	1. 156	1. 370	1. 562	1. 78	
20. 00		. 375	. 500	. 593	. 812	1. 030	1. 281	1. 500	1. 750		
24. 00		. 375	. 562	. 687	. 968	1. 210	1. 531	1. 810			

Information
Sheet # 23

Information Sheet
on
MILITARY STANDARD NONDESTRUCTIVE TESTING
SYMBOLS-MIL - STD - 23A 25 August, 1952

Obtained from:
Munitions Board
Standards Agency
Department of Defense
Washington 25, D. C.

MIL-STD-23A
25 August 1952

SUPERSEDING
MIL-STD-23
27 November 1950

MILITARY STANDARD

NONDESTRUCTIVE TESTING SYMBOLS

MUNITIONS BOARD STANDARDS AGENCY
DEPARTMENT OF DEFENSE
Washington, D. C.

25 August 1952

Nondestructive Testing Symbols
MIL-STD-23A

1. This standard has been approved by the Departments of the Army, the Navy, and the Air Force, and establishes the symbols for use on drawings to specify nondestructive tests for determining the soundness of materials.

2. The Munitions Board Standards Agency on 25 August 1952 approved the revision of this standard for printing.

3. In accordance with established procedure the Munitions Board Standards Agency has designated the Ordnance Corps, Bureau of Ships, and the Department of the Air Force, respectively, as Army-Navy-Air Force custodians of this standard.

4. This revised standard is mandatory for use effective 25 August 1952. Where repeated deviation from the approved Military Standard is granted by a department, a report shall be made to the Munitions Board Standards Agency by that department with the reasons for deviation.

5. Recommended corrections, additions, or deletions should be addressed to the Director, Munitions Board Standards Agency, Washington 25, D. C.

CONTENTS

FIGURES

TABLE

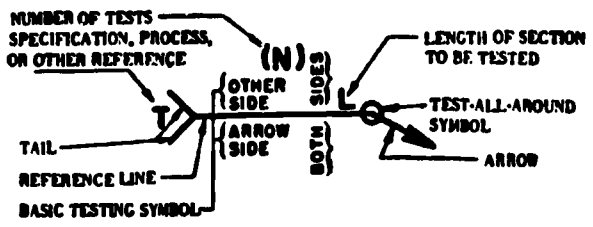
1. BASIC SYMBOLS

1.1 BASIC TESTING SYMBOLS. Basic Nondestructive Testing symbols shall be as shown in table I.

TYPE OF TEST	SYMBOL
RADIOGRAPHIC	RT
MAGNETIC-PARTICLE	MT
PENETRANTS	PT
ULTRASONIC	UT

1.2 ELEMENTS OF THE TESTING SYMBOL. The assembled testing symbol consists of the following elements. Such of these elements as are necessary shall be used and shall have standard locations with respect to each other as shown on figure 1.

Reference Line
Arrow
Basic Testing symbol
Test-all-around symbol
(N) Number of Tests
Tail
Extent of test
Specification, process, or other reference

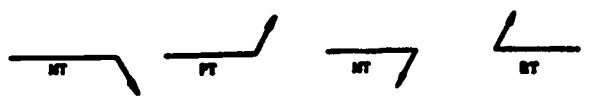


2. GENERAL PROVISIONS

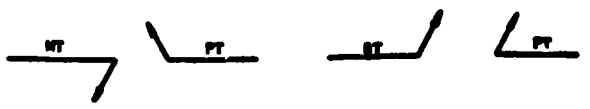
2.1 SIGNIFICANCE OF ARROW. The arrow shall connect the reference line to the part to be tested. The side of the part to be tested, to which the arrow points shall be considered the arrow side of the part. The side opposite the arrow side of the part shall be considered the other side.

2.2 LOCATION OF TESTING SYMBOL.

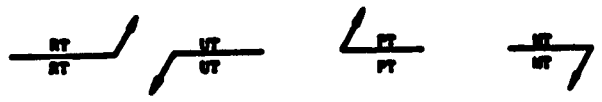
2.2.1 Tests to be made on the arrow side of the part shall be indicated by the test symbol on the side of the reference line toward the reader as follows:



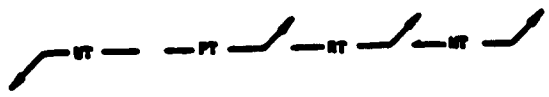
2.2.2 Tests to be made on the other side of the part shall be indicated by the test symbol on the side of the reference line away from the reader as follows:



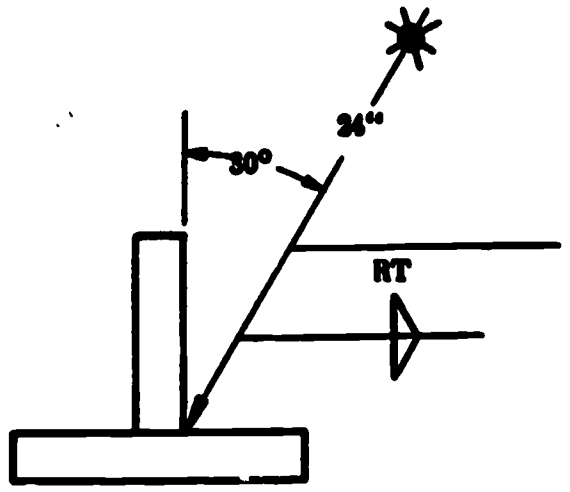
2.2.3 Tests to be made on both sides of the part shall be indicated by test symbols on both sides of the reference line, as follows:



2.2.4 When nondestructive testing symbols have no arrow or other-side significance, the testing symbols shall be centered on the reference line as follows:

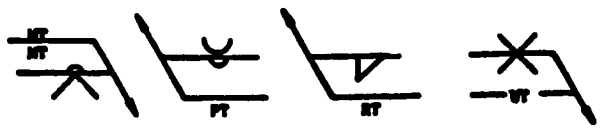


2.3 **DIRECTION OF RADIATION.** When specified, the location of the source of radiation and the direction of radiation shall be shown in conjunction with radiographic testing symbol. The location of the source of radiation shall be indicated by a symbol located on the drawing at the desired source of radiation, connected, and oriented as necessary by dimensions, as shown on figure 2.

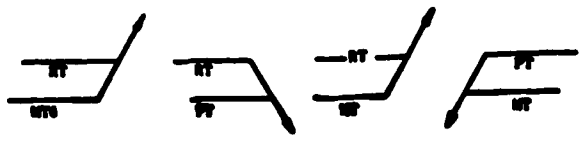


2.4 **COMBINATION OF NONDESTRUCTIVE TESTING SYMBOLS AND WELDING SYMBOLS**

2.4.1 Nondestructive testing symbols and welding symbols may be combined as follows:



2.4.2 Nondestructive testing symbols may be combined as follows:



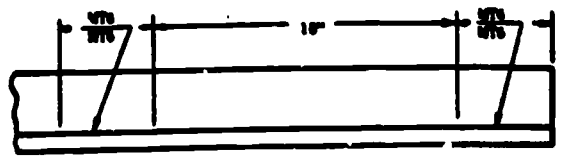
2.5 USE OF REFERENCES. Specifications, process, classification, or other references need not be used on testing symbols when the testing procedure is prescribed elsewhere. When a specification, process, classification, or other reference is used with a testing symbol, the reference shall be placed in the tail, as follows:

3. METHODS OF SPECIFYING EXTENT OF NONDESTRUCTIVE TESTS

3.1 SPECIFYING LENGTH OF SECTION TO BE TESTED

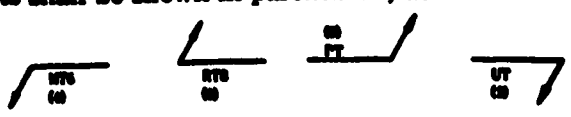
3.1.1 To specify tests of welds or parts where only length of section need be considered, the length in inches shall be shown to the right of the basic test symbol, as follows:

3.1.2 To show the exact location of a section to be tested as well as its length, dimension lines shall be used as follows:



3.1.3 When the full length of a part is to be tested, no length dimension need be shown on the testing symbol.

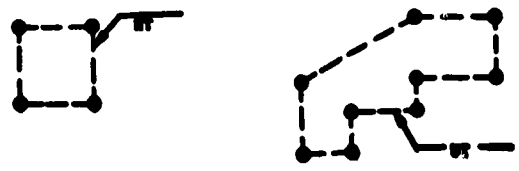
3.2 SPECIFYING NUMBER OF TESTS. To specify a number of tests to be taken at random, the number of desired tests shall be shown in parenthesis, as follows:



3.3 SPECIFYING TESTS MADE ALL AROUND A PART. To specify tests to be made all around a part, the test-all-around symbol shall be used, as follows:

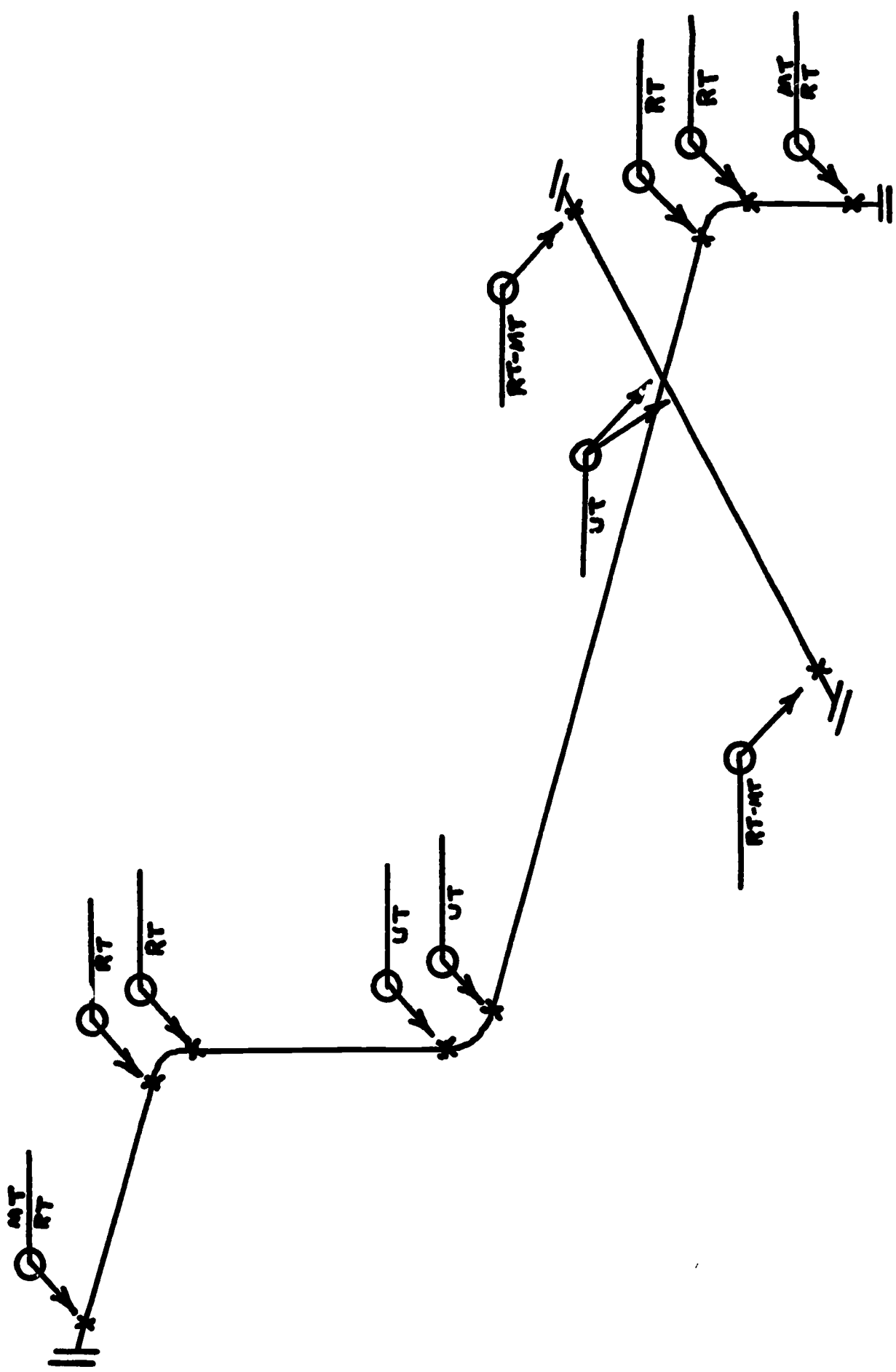
3.4 SPECIFYING TESTS OF AREAS. When required, nondestructive tests of areas shall be indicated by one of the following methods:

3.4.1 For nondestructive testing of an area represented as a plane on the drawing, the area to be tested shall be enclosed by straight broken lines having a circle at each change of direction. The testing symbol specifying the kind of nondestructive test shall be used in connection with these lines, as shown below. When necessary, these inclosures shall be located by dimensions.



Information Sheet
on
NONDESTRUCTIVE TESTING SYMBOL
TEST SHEET

Information
Sheet # 24

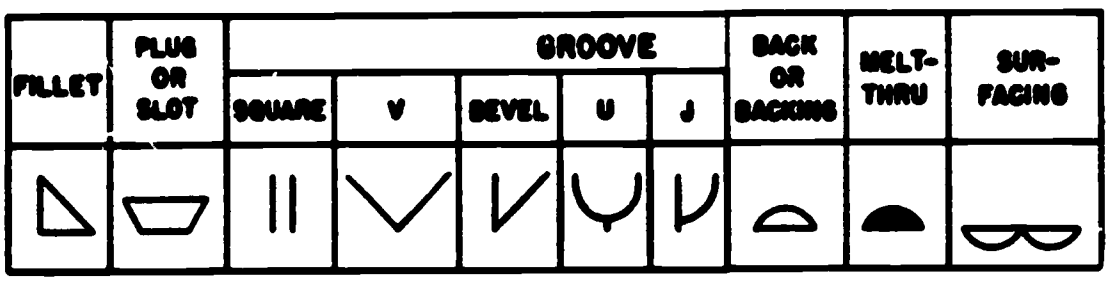


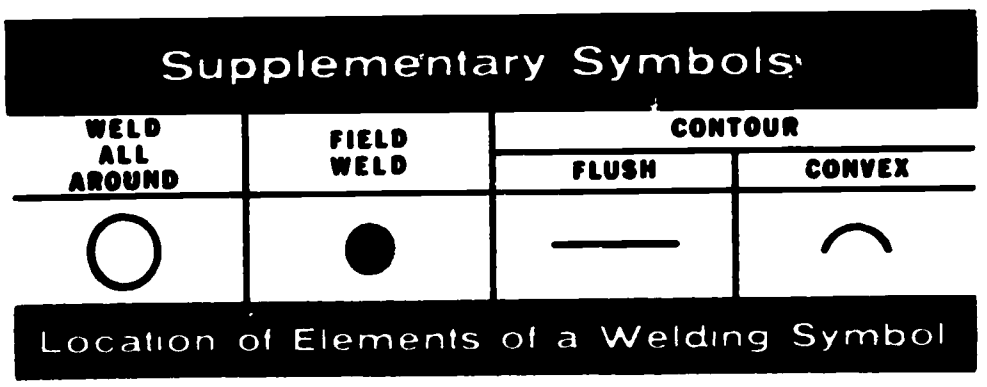
Information Sheet
on
WELDING SYMBOLS AND SIZES

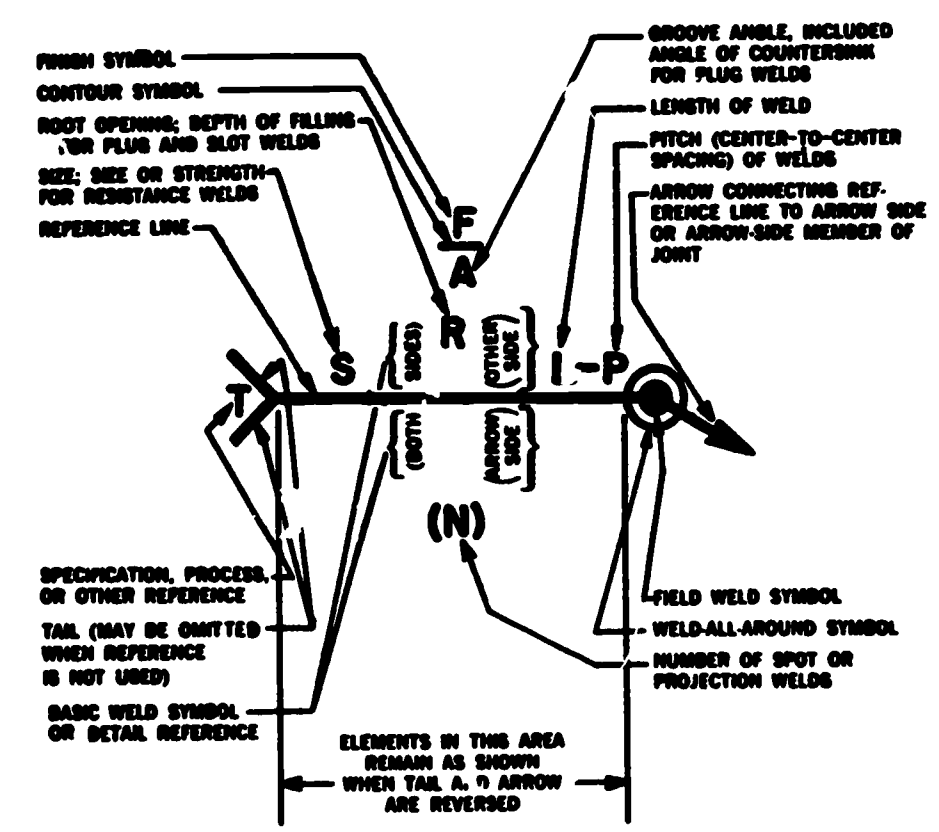
Information Sheet # 25

The first step in making a good weld is to know what the designer wants. The welding symbols used on prints are a simple, exact method of indicating welds and weld sizes, and you must be able to specify and read them correctly. Here is a brief summary of some of the more commonly used welding symbols:

Basic Arc and Gas Weld Symbols

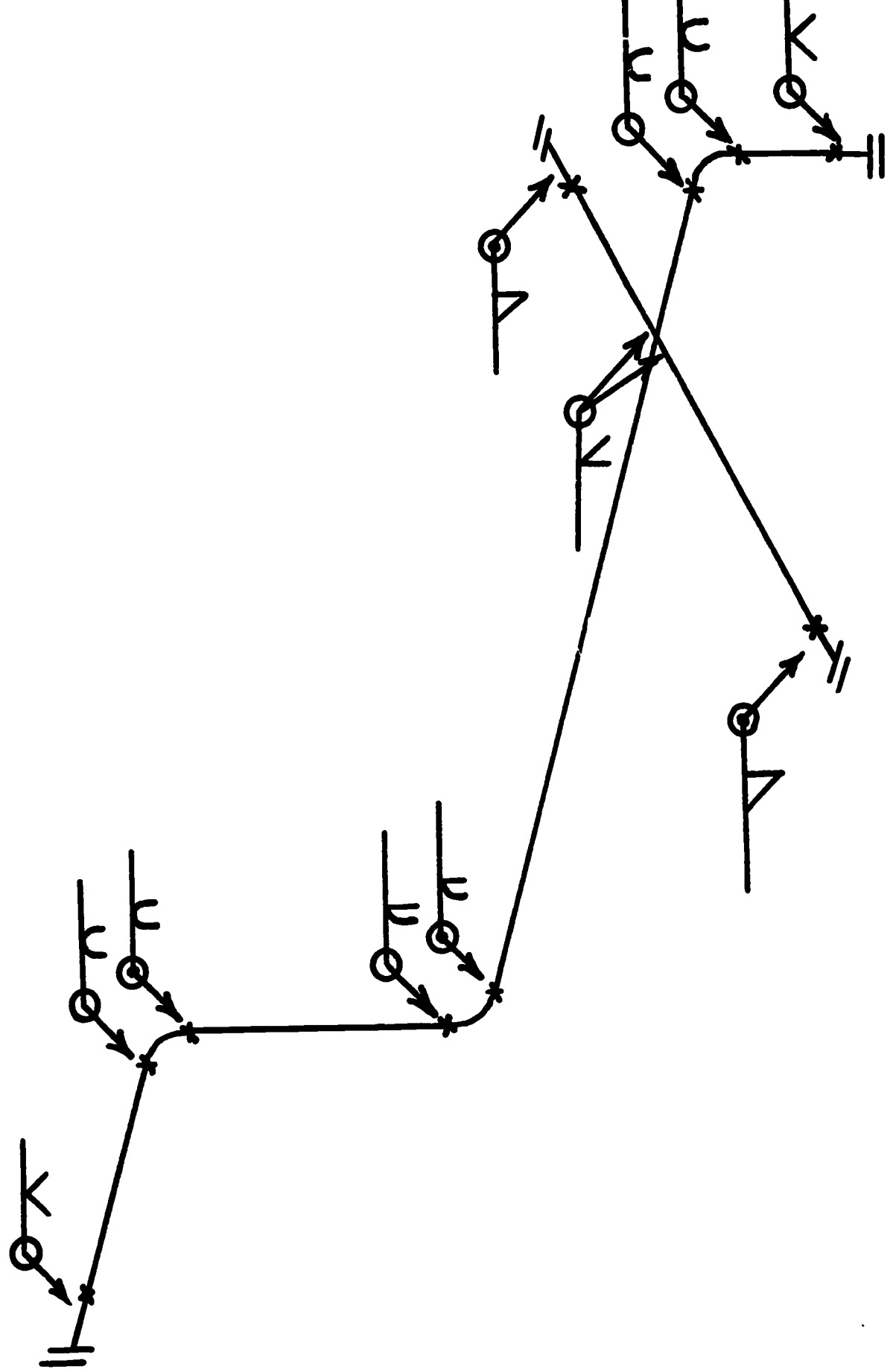






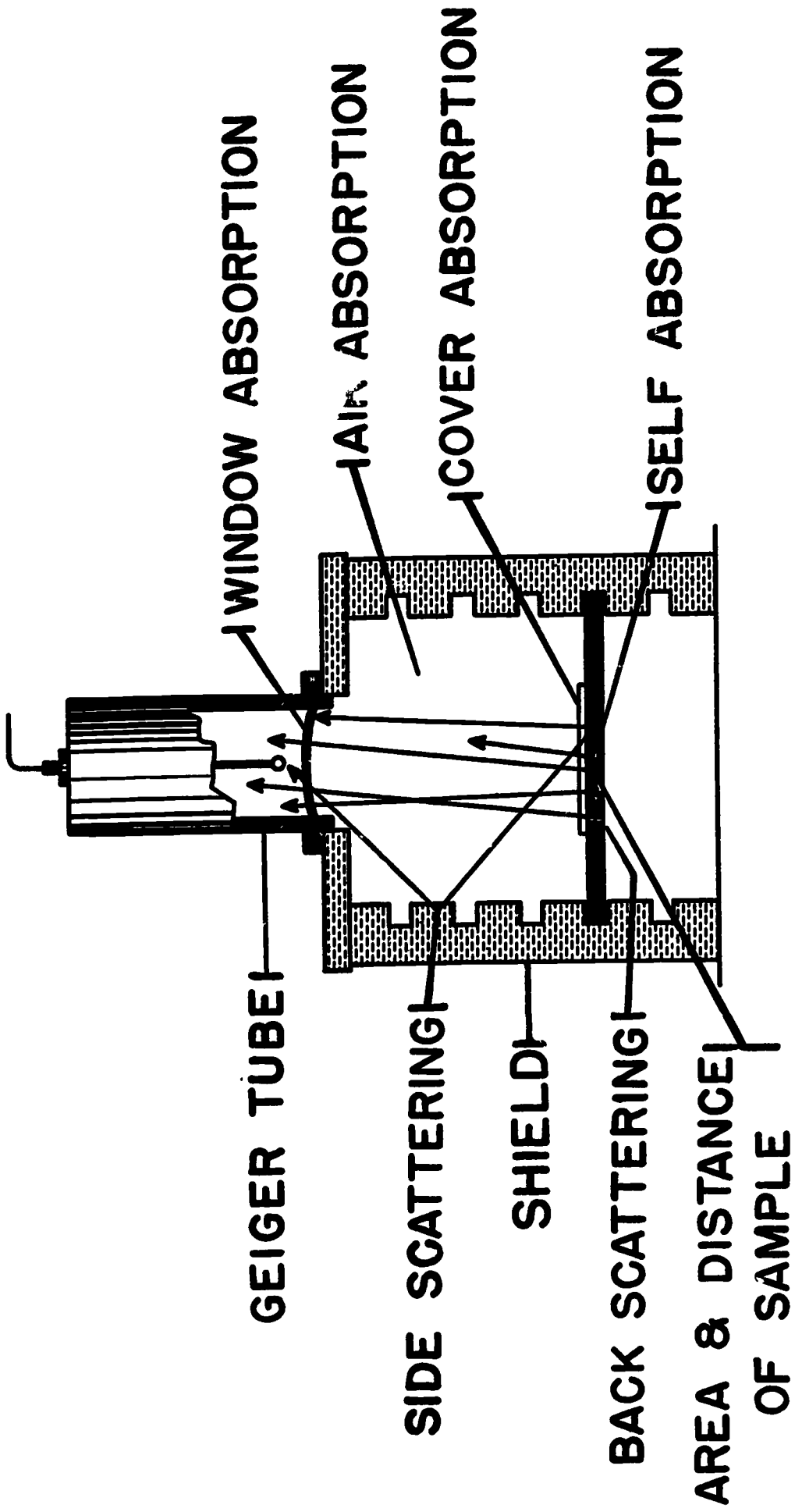
Information Sheet
on
WELDING SYMBOLS TEST SHEET

Information
Sheet # 26



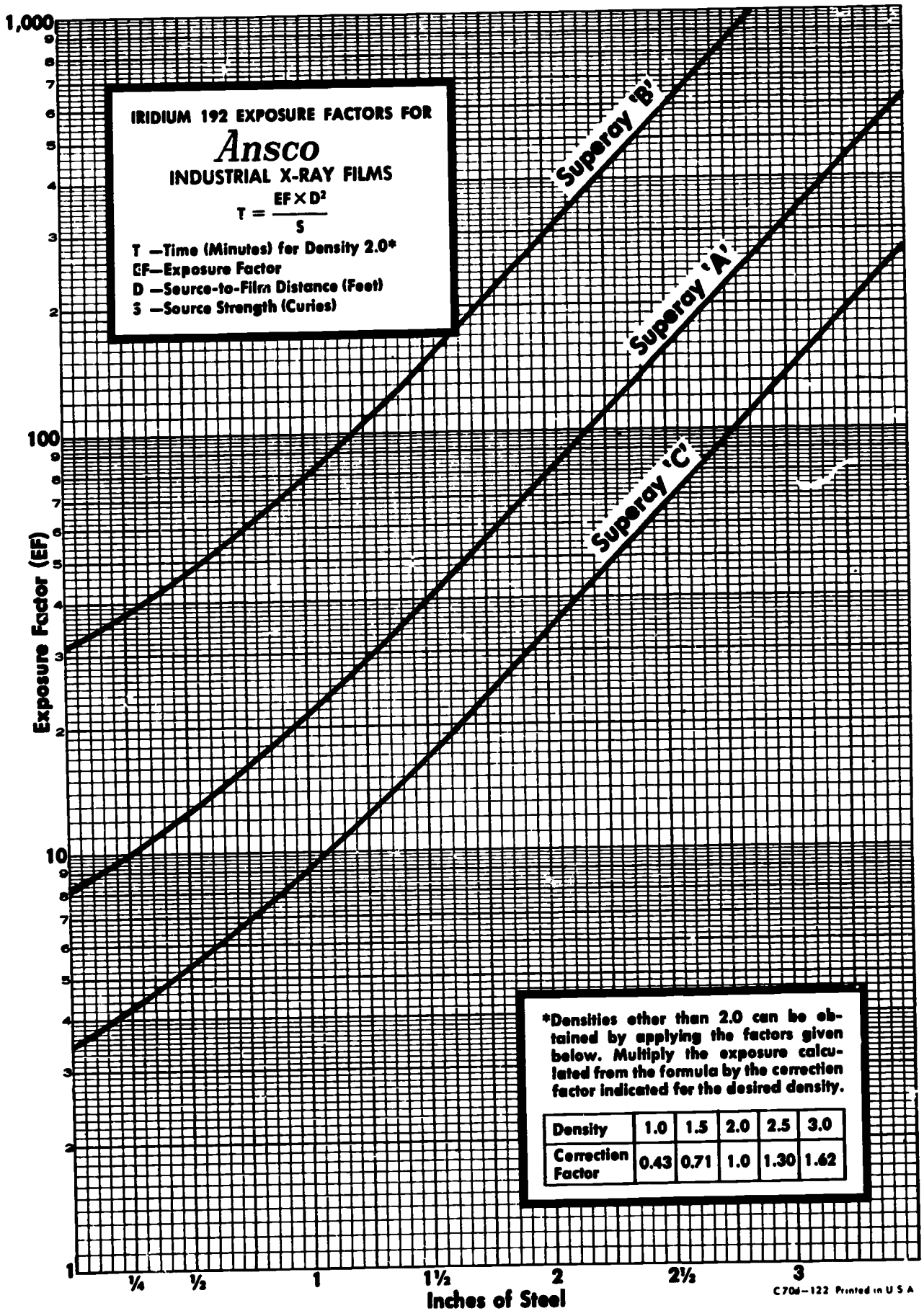
Information Sheet
on
CONSIDERATIONS IN RADIOACTIVITY MEASUREMENTS

Information
Sheet # 27



Information Sheet
on
ANSCO EXPOSURE FACTORS FOR
IRIDIUM[192]

Information
Sheet # 28



Information Sheet
on

TYPICAL EXPOSURE FACTOR FOR PIPE AND PLATE
(KODAK TYPE AA FILM)

Information Sheet # 29

Inches of Steel	Kodak "AA" Factor	Pipe Size	Pipe Square of Distance	Flat Plate
1/8	41	3"	11"	9"
1/4	48	4"	19"	16"
3/8	58	5"	30"	25"
1/2	70	6"	44"	36"
5/8	81	8"	75"	64"
3/4	97	10"	116"	100"
7/8	115	12"	163"	144"
1-	138	14"	196"	196"
1-1/8	160	16"	256"	256"
1-1/4	196	18"	324"	324"
1-3/8	230	20"	400"	400"
1-1/2	270	22"	484"	484"
1-5/8	320	24"	576"	576"
1-3/4	380	26"	676"	676"
1-7/8	450	28"	784"	784"
2-	530	30"	900"	900"
2-1/8	630	32"	1024"	1024"
2-1/4	740	34"	1156"	1156"
2-3/8	900	36"	1296"	1296"
2-1/2	1050			
2-5/8	1250			
2-3/4	1405			
2-7/8	1750			
3-	2050			

Note: These factors can be used under the following conditions:
(a) Developing time 5 minutes @ 68° F.
(b) H & D Density of base metal-1. 5
(c) Ir. 192 Gamma Radiation
(d) Radiation source must be within 1/2" of near pipe wall for exposure of far side of pipe wall.
(e) Always figure a total of 2 wall thicknesses for this type exposure because radiation is passing through both walls although exposure is made of one wall only. (This applies to pipe)
(f) Density may vary slightly depending on brand and condition of chemicals.

Note: Although nominal pipe diameter varies with the actual pipe size, this variation ceases with 14" pipe. Example: 10" pipe is actually 10. 75 inches in outside diameter; 14" pipe is 14 inches in outside diameter.

Information Sheet
on
MATERIAL DENSITY FACTORS

Information Sheet # 30

Multiply the thickness of material by the multiplier to find the equivalent thickness of steel.

Material	Multiplier
Copper	1. 14
Nickel	1. 13
Monel	1. 12
Bronze	1. 12
Inconel	1. 08
Free-cutting Brass	1. 08
Stainless Steel	1. 02
Titanium	0. 58
Aluminum	0. 34
Magnesium	0. 22

Information Sheet
on
COLLIMATION EFFECT ON EXPOSURE TIME

Information Sheet # 31

1. Collimation requires an increase in exposure time.
   a. Experiment done with AA film, no lead screens
   b. 851 curie Cobalt^{60} source, 2.0 density 5'4" F. F. D.

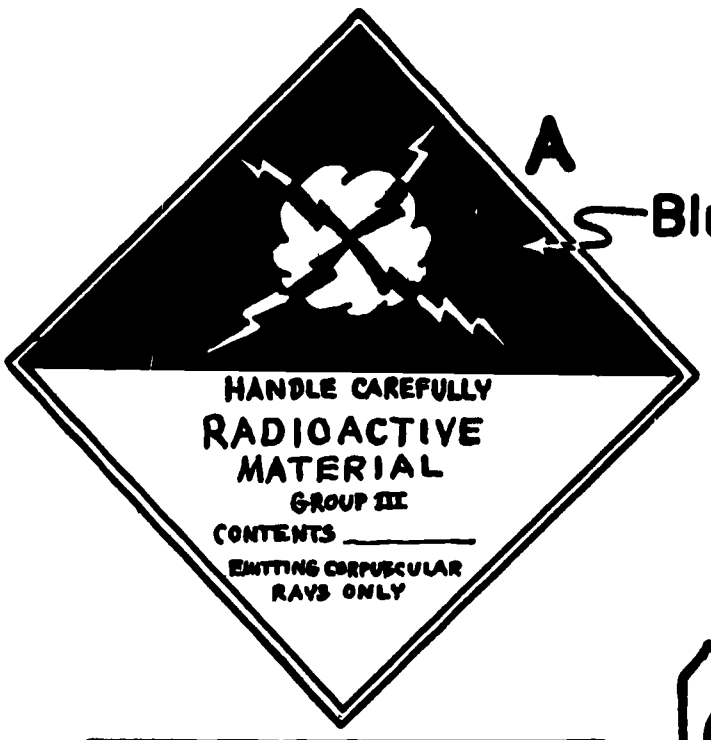
Steel Thickness	Collimator Size	Exposure Time
10"	None	3.9 hours
10"	18" x 18"	8.0 "
10"	11 1/2" x 11 1/2"	10.0 "
10"	4" x 4"	19.0 "
7"	None	19.5 minutes
7"	18" x 18"	31.0 "
7"	11 1/2" x 11 1/2"	40.0 "
7"	4" x 4"	60.0 "
5"	None	4.25 "
5"	18" x 18"	4.7 "
5"	11 1/2" x 11 1/2"	5.8 "
5"	4" x 4"	8.5 "

Develop 7 minutes @ 70° F.

2. The collimation effect increases with increased thickness.
   a. Increases sensitivity
   b. Increases latitude

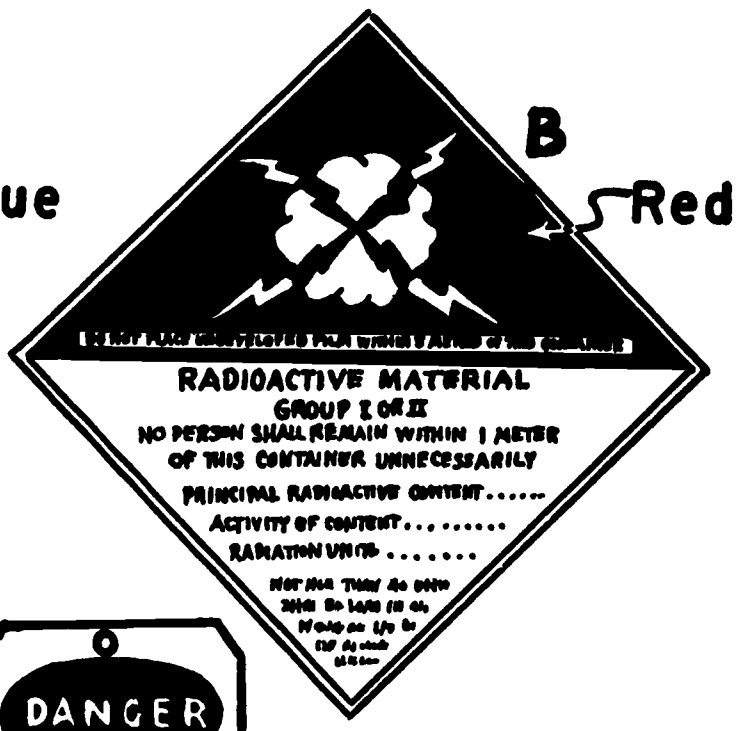
Information Sheet
on
RADIATION WARNING SIGNS AND SHIPPING TAGS

Information
Sheet # 32



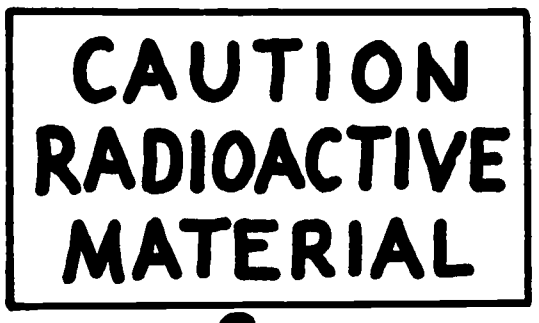
A

Blue



B

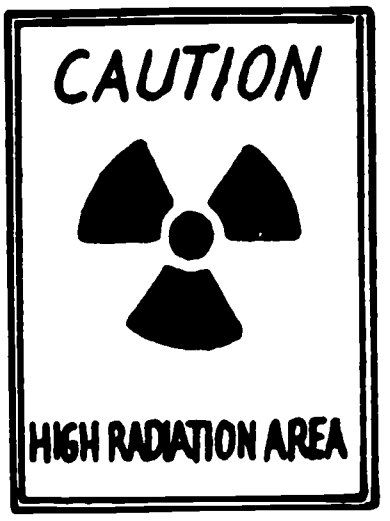
Red



C

D

E



A. Interstate Commerce Commission Blue label shipping placard.
B. Interstate Commerce Commission Red label shipping placard.
C. Placard for motor vehicle carrying radioactive materials.
D. Tag for radioisotopes.
E. Various warning signs displayed by radioisotope users.

Information Sheet
on
RADIATION CAUTION SIGN

Information
Sheet # 33

The radiation warning symbol is a purple colored propeller-shaped figure upon a yellow background. The wording on different radiation warning signs may vary but the symbol is standard.

TRC Form 21-1
(3-63)

Texas State Department of Health
1100 West 49th Street
Austin 56, Texas

NOTICE TO EMPLOYEES

TEXAS REGULATIONS FOR CONTROL OF RADIATION

The Texas State Department of Health has established standards for your protection against radiation hazards, pursuant to the Texas Radiation Control Act, Art. 4590f, Revised Civil Statutes, State of Texas.

YOUR EMPLOYER'S RESPONSIBILITY

Your employer is required to--

1. Apply these regulations to work involving sources of radiation.
2. Post or otherwise make available to you a copy of the Texas State Department of Health regulations, licenses, and operating procedures which apply to work you are engaged in, and explain their provisions to you.

YOUR RESPONSIBILITY AS A WORKER

You should familiarize yourself with those provisions of the regulations and the operating procedures which apply to the work you are engaged in. You should observe their provisions for your own protection and protection of your co-workers.

WHAT IS COVERED BY THESE REGULATIONS

1. Limits on exposure to radiation and radioactive material in restricted and unrestricted areas;
2. Measures to be taken after accidental exposure;
3. Personnel monitoring, surveys and equipment;
4. Caution signs, labels, and safety interlock equipment;
5. Exposure records and reports; and
6. Related matters.

REPORTS ON YOUR RADIATION EXPOSURE HISTORY

1. The regulations require that your employer give you a written report if you receive an exposure in excess of any applicable limit as set forth in the regulations or in the license. The basic limits for exposure to employees are set forth in Section 21.101, 21.103, and 21.104 of the regulations. These sections specify limits on exposure to radiation and exposure to concentrations of radioactive material in air and water.

2. If you work where personnel monitoring is required,
   (a) Your employer must give you a written report, upon termination of your employment, of your radiation exposures, and
   (b) Your employer must advise you annually of your exposure to radiation.

INSPECTIONS

All licensed or registered activities are subject to inspection by representatives of the Texas State Department of Health.

INQUIRIES

Inquiries dealing with the matters outlined above can be sent to the Texas State Department of Health, Division of Occupational Health and Radiation Control, 1100 West 49th Street, Austin 56, Texas.

POSTING REQUIREMENT

Copies of this notice must be posted in a sufficient number of places in every establishment where employees are employed in activities licensed or registered pursuant to Part 41 of Texas Regulations for Control of Radiation, by the Texas State Department of Health, to permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.

Information Sheet
on
NOTICE TO EMPLOYEES SIGN

Information Sheet # 34

Information Sheet
on
SAMPLE REPORT FORM

Information
Sheet # 35

CURRENT OCCUPATIONAL EXTERNAL RADIATION EXPOSURE

Identification

1. Name (Print--Last, First. and Middle	2. Social Security No.
Doe, John J.	404-61-9080
3. Date of Birth (Month. Day. Year	**4. Name of Licensee or Registrant**
3 16 1922	Ajax Testing Labs.

Occupational Exposure

5. Dose Recorded for (Specify: Whole Body skin of whole body; or hands and forearms, feet and ankles.)	6. Whole Body Dose Status (rem)	7. Method of Monitoring (e.g., ✓ Film Badge--FB; ✓ Pocket Chamber--PC; Calculations--Calc.) X or GAMMA ✓ BETA ✓ NEUTRONS
whole body	14	

8. Period of Exposure (From-To)	Dose for the Period (rem) 9. X or Gamma	10. Beta	11. Neutron	12. Total	13. Running Total for Calendar Quarter (rem)
6-1-63 to 8-1-63	✓	✓		3	3
8-1-63 To 9-1-63	✓	✓		4	7

Lifetime Accumulated Dose

14. Previous Total (rem)	15. Total Quarterly Dose date rem	16. Total Accumulated Dose (rem)	17. Perm. Acc. Dose 5(n-18) (rem)	18. Unused Part of Permissible Accumulated Dose (rem)
14	7	21	120	99

Information Sheet
on
SAMPLE REPORT FORMS

Information
Sheet # 36

YEARLY EXPOSURE SUMMARY

Year	Film Badge 1 MR	Dosi-meter 1 MR	Film Badge 2	Dosi-meter 2	Film Badge 3	Dosi-meter 3	Film Badge 4	Dosi-meter 4
January	160	180						
February	120	130						
March	170	150						
1st Quarter	450	460						
April	600	550						
May	100	90						
June	110	100						
2d Quarter	810	740						
July	410	300						
August	660	700						
September	360	400						
3d Quarter	1430	1400						
October	200	200						
November	160	150						
December	150	140						
4th Quarter	510	490						
Yearly Total	3,200 MR or 3.2 REM	3090 MR or 3.09 REM						

DAILY DOSIMETER READING

Name John Doe Date 4-2-64
Work Week Beginning

Serial Number	Date		Dosimeter Reading in Milliroentgens		Daily Exposure
			Start	Finish	
166	Monday	4-2	0	30	30
✓	Tuesday	4-3	30	70	40
✓	Wednesday	4-4	0	25	25
✓	Thursday	4-5	25	60	35
✓	Friday	4-6	60	100	40
✓	Saturday	4-7	0	100	100
✓	Sunday	4-8	—	—	—
				Total Weekly Exposure	270 MR

John Doe
Signature

Information Sheet
on
SAMPLE REPORT FORMS

Information
Sheet # 37

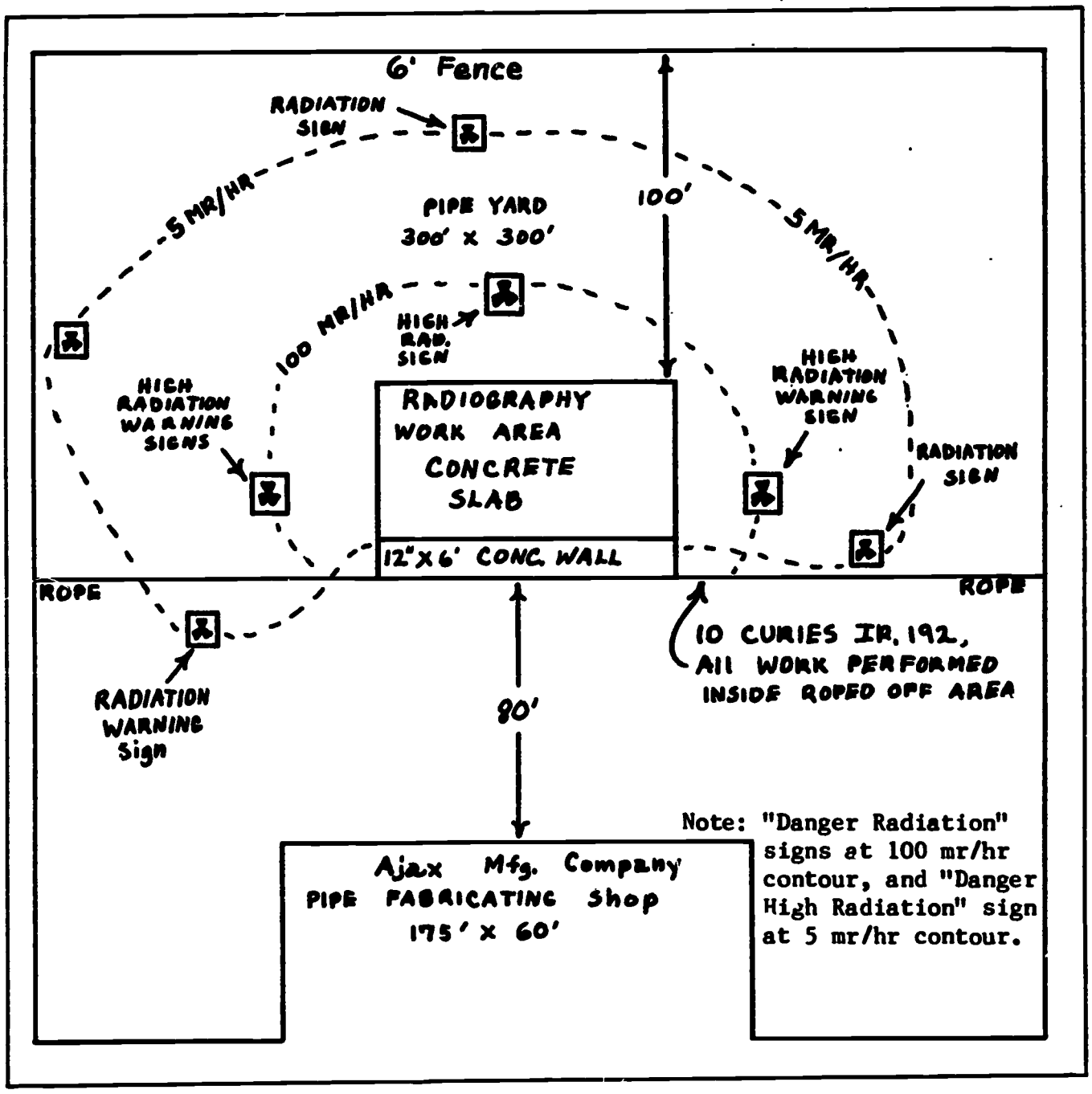
AREA SURVEY RECORD

Radioactive Material IR. 192 Source No. 75

Container and/or Radiographic Device No. or Model KELRAY CC #10

Date of Survey 3-1-64 Survey Instrument No. # 14

Location AJAX Mfg. Co. PIPE FABRICATING YARD HOUSTON, TEXAS



Note: "Danger Radiation" signs at 100 mr/hr contour, and "Danger High Radiation" sign at 5 mr/hr contour.

Quarterly Inventory

Radioactive Material IR. 192 Source No. ORNL 11A

Activity at Date of Purchase 30,000 M/CURIES

Container and/or Radiographic Device No. or Model KEL RAY MODEL-CC#2

Date of Inventory	Activity in Millicuries	Location	Date Received	Disposal Date
5-1-64	5,000	XYZ LABS Austin, Texas	11-1-63	6-1-64

Information Sheet
on
SAMPLE REPORT FORMS

Information
Sheet # 38

LEAK TEST RECORDS

Radioactive Material Iridium 192 Source No. 75

Activity at Time of Purchase 30 curies

Container and/or Radiographic Device No. or Model Kelray CC #10

Leak Test perfromed by John Doe

Date Tested	Test Results Microcuries	Activity. Millicuries	Remarks
3-1-64	Negative	3,000	No reading above background

UTILIZATION LOG

Radioactive Material Iridium 192 Source No. 75

Activity of Source 30 curies

Container and/or Radiographic Device No. or Model Kelray C C #10

Name of User	Date Out	Location	Date In	Initials
John Doe	3-1-64	Ajax Mfg. Co.	3-2-64	J. D.

STORAGE SECURITY AND UTILIZATION LOG FOR IN-PLANT RADIOGRAPHY

Location AJAX Testing LABS. Austin, Texas

Container and/or Radiographic Device No. or Model Kelray CC #10

Name of User	Source Material	Source Out		Source In		Radiation Level	Source Secure Initials
		Date	Time	Date	Time		
John Doe	IR. 192	2-2-64	9:00AM	2-2-64	4:00PM	17.2 Curies	John Doe

Information Sheet
on
SAMPLE REPORT FORMS

Information
Sheet # 39

SURVEY OF SOURCE STORAGE

Radioactive Material IR. 192 Source No. 75

Activity at Time of Purchase 30 curies

Container and/or Radiographic Device No. or Model Kelray C.C. #10

Leak Test performed by John Doe

Date Tested	Test Results Microcuries	Activity Millicuries	Remarks
3-1-64	Negative (below .05 uc)	6,000	No meter indication Above background

INSTRUMENT CALIBRATION RECORD

Instrument Type: IONIZATION Type Survey Meter

Instrument Model: SR50

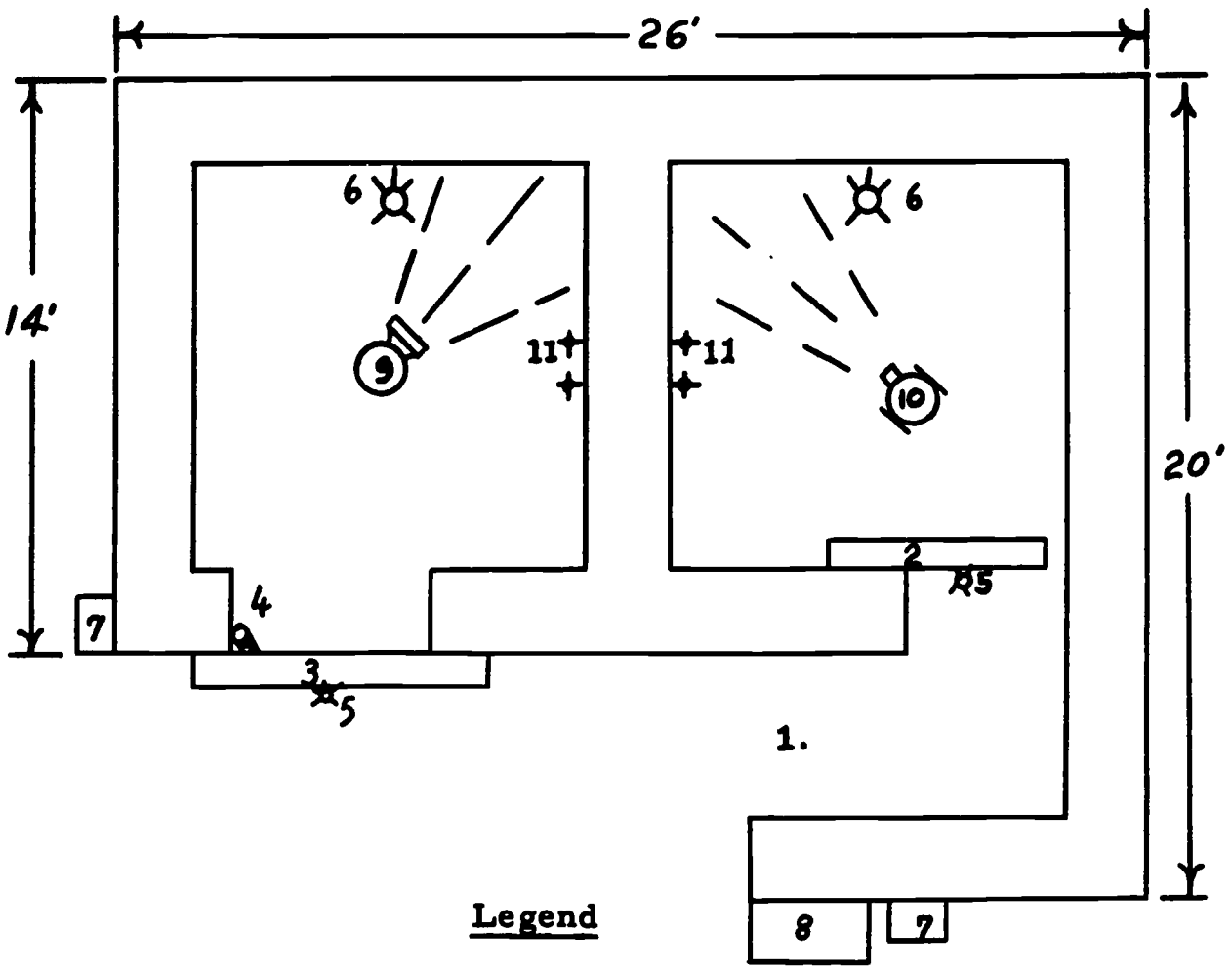
Serial Number: 1765

Range 0-50 R/HR Year 1964

Date Calibrated	Calibrated By	Remarks
3-1-64	John Doe	CalibRATED @ 1, 2++ FT. on MR/HR Range and @ 1' on MR/HR Range using - MG RADIUM

Information Sheet
on
SUGGESTED LAYOUT OF EXPOSURE FACILITIES

Information
Sheet # 40

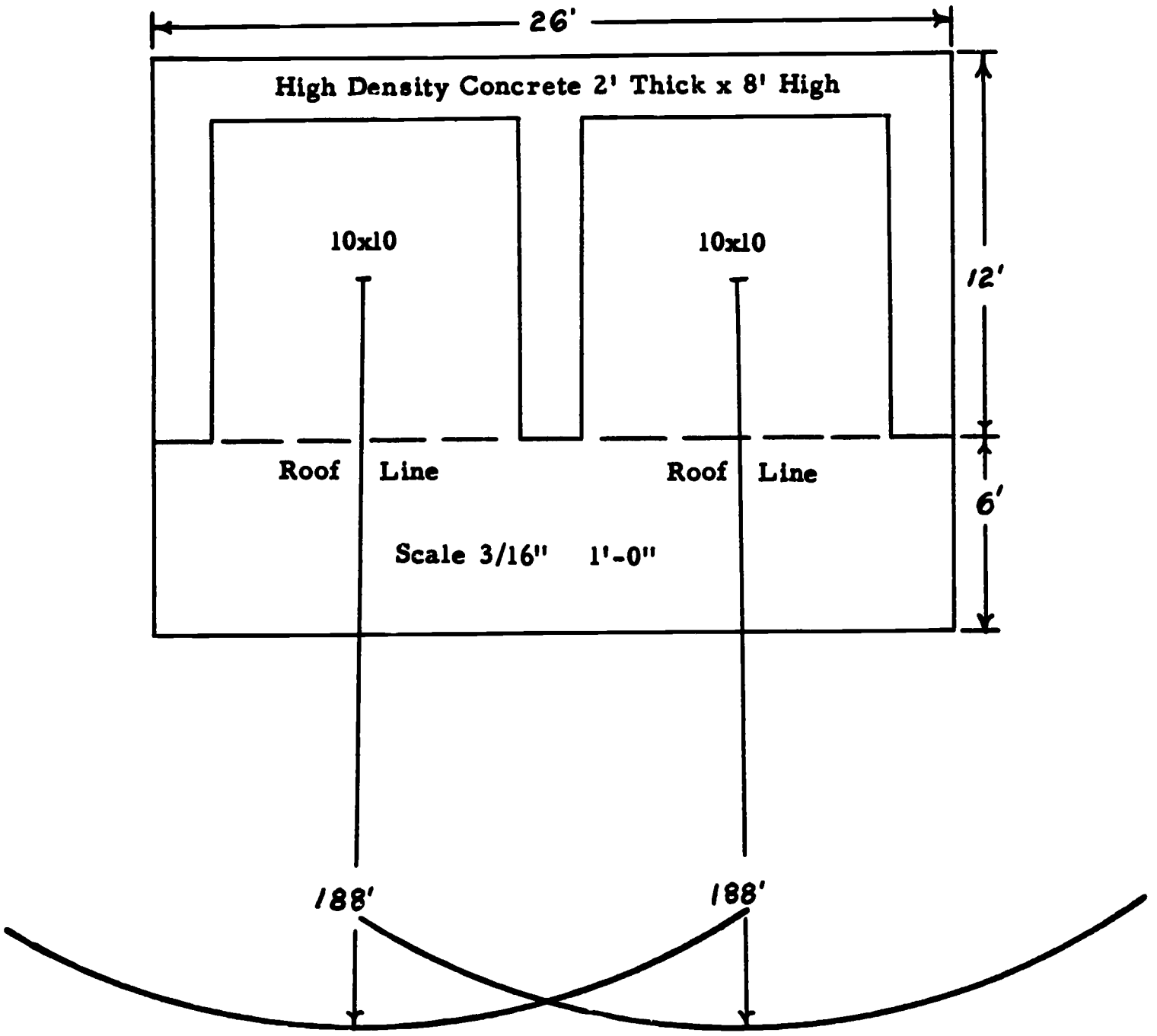


Legend

1. Labyrinth for bringing in heavy objects with a fork lift.
2. Sliding lead sandwich door.
3. Sliding lead sandwich door.
4. Safety switch shuts off power to X-Ray generator when door is opened.
5. Red warning lights on doors while exposure is being made.
6. Lights.
7. Radiation Monitor, 110 volt AC power supply.
8. X-Ray controls.
9. X-Ray generator.
10. Gamma Ray exposure device.
11. Cooling water taps for X-Ray head.

Note: Lead sheets on floor and walls are desirable, expecially in X-Ray exposure room, to reduce scatter. If this facility is built inside a building containing upper floors it may be necessary to provide a permanent roof to shield the floors above this facility. If built as a separate building, an attenuation survey should include the roof. Warning signs and a fence around the roof are desirable.

INDOOR FACILITIES



5 mr/hr Boundary

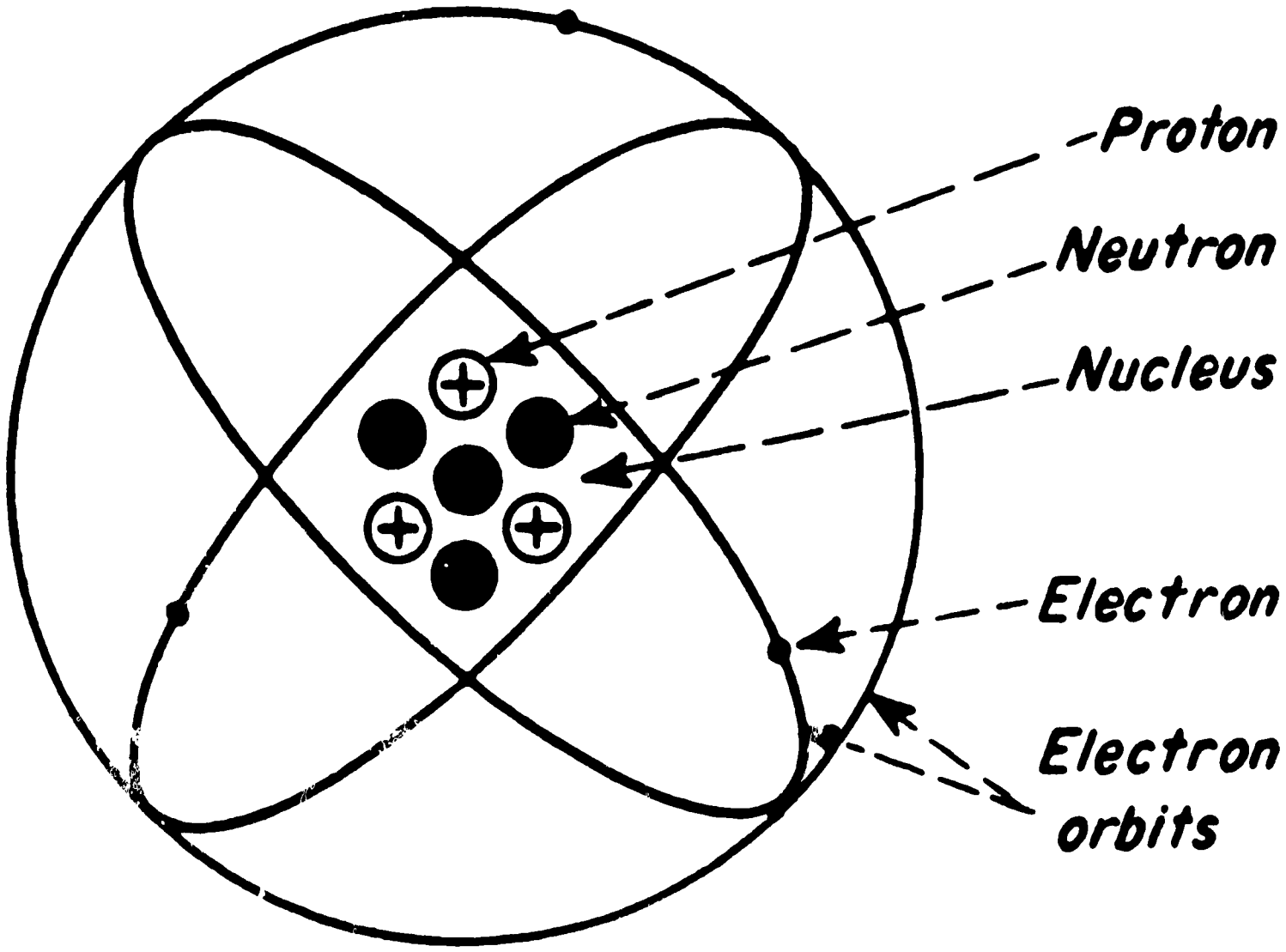
Attenuation factor for 24" concrete equals 10,000 for ir. 192.

With 30 curies ir. 192 positioned in center of cell, reading at outside surface of walls would be less than 1/2 mr/hr.

OUTDOOR FACILITIES

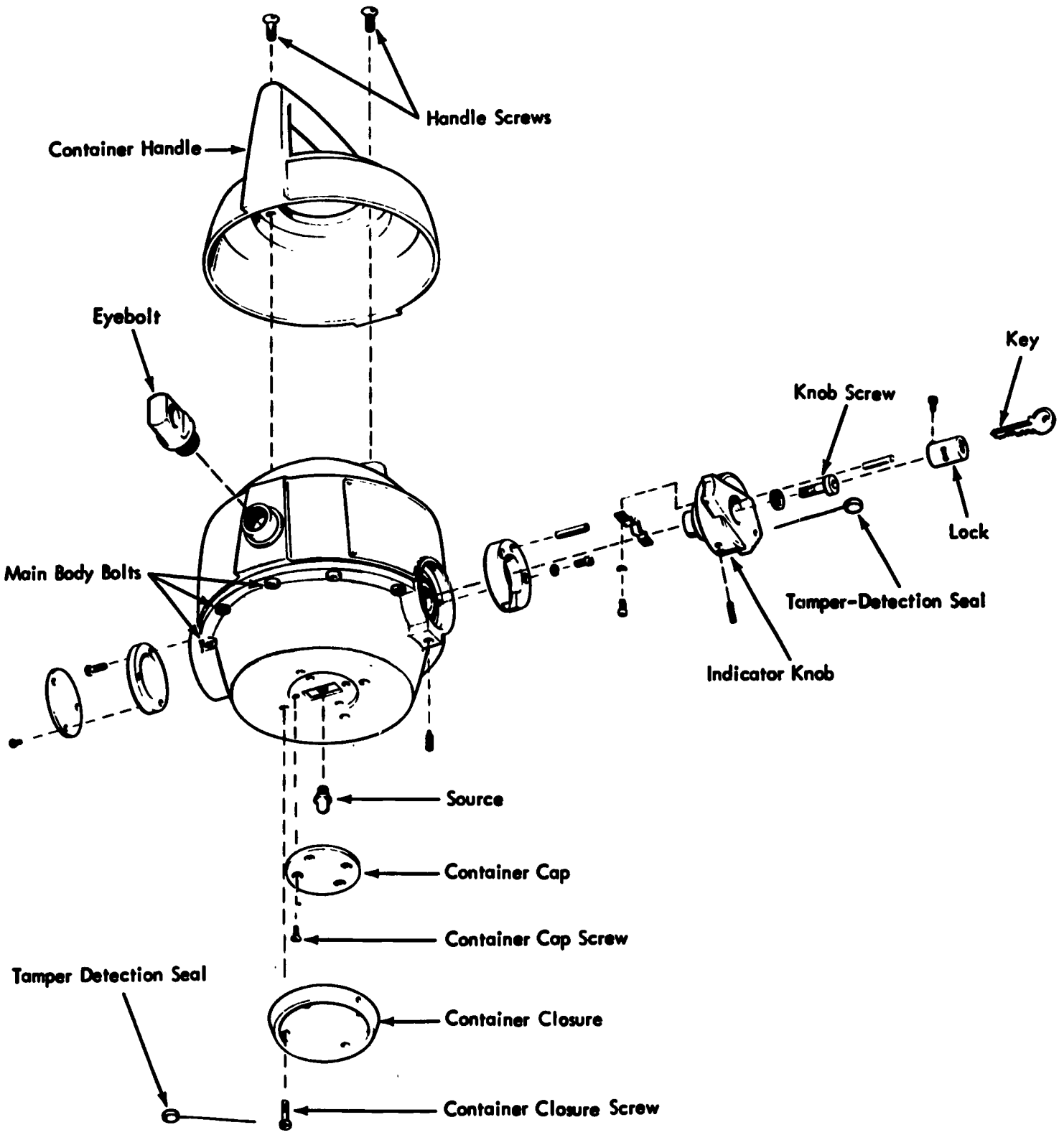
Information Sheet
on
STRUCTURE OF THE ATOM

Information
Sheet # 41

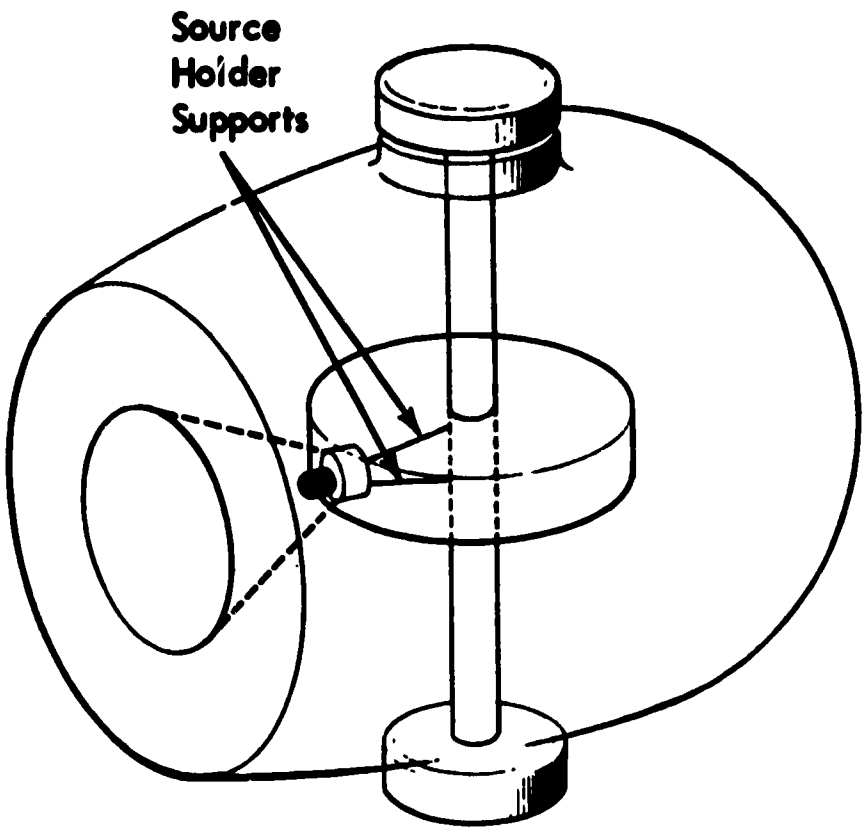


Information Sheet
on
MODEL CC PROJECTOR

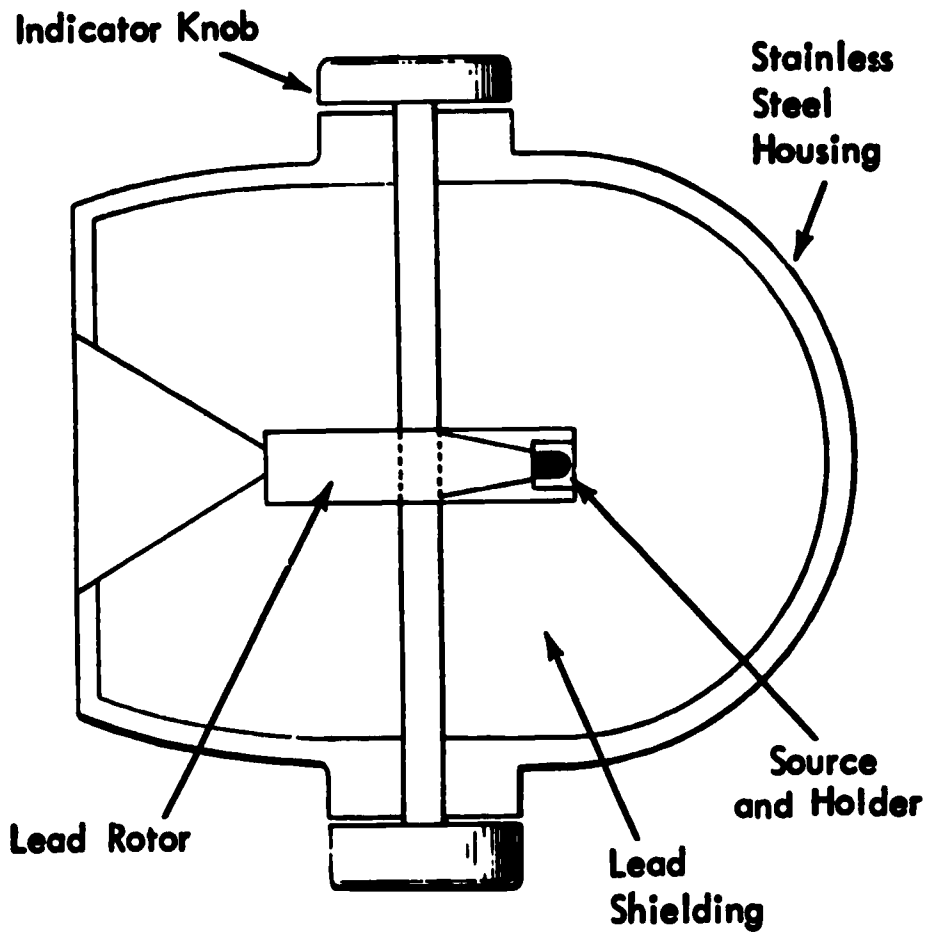
Information
Sheet # 42



EXPLODED VIEW OF THE MODEL CC PROJECTOR



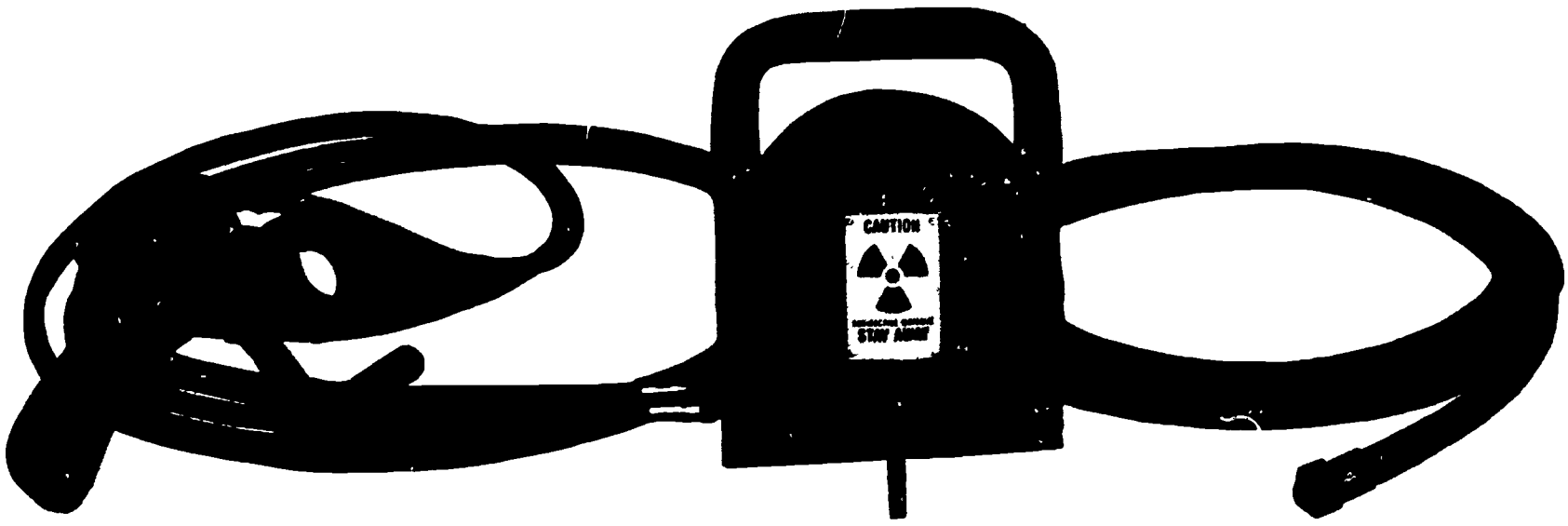
SOURCE IN "ON" POSITION



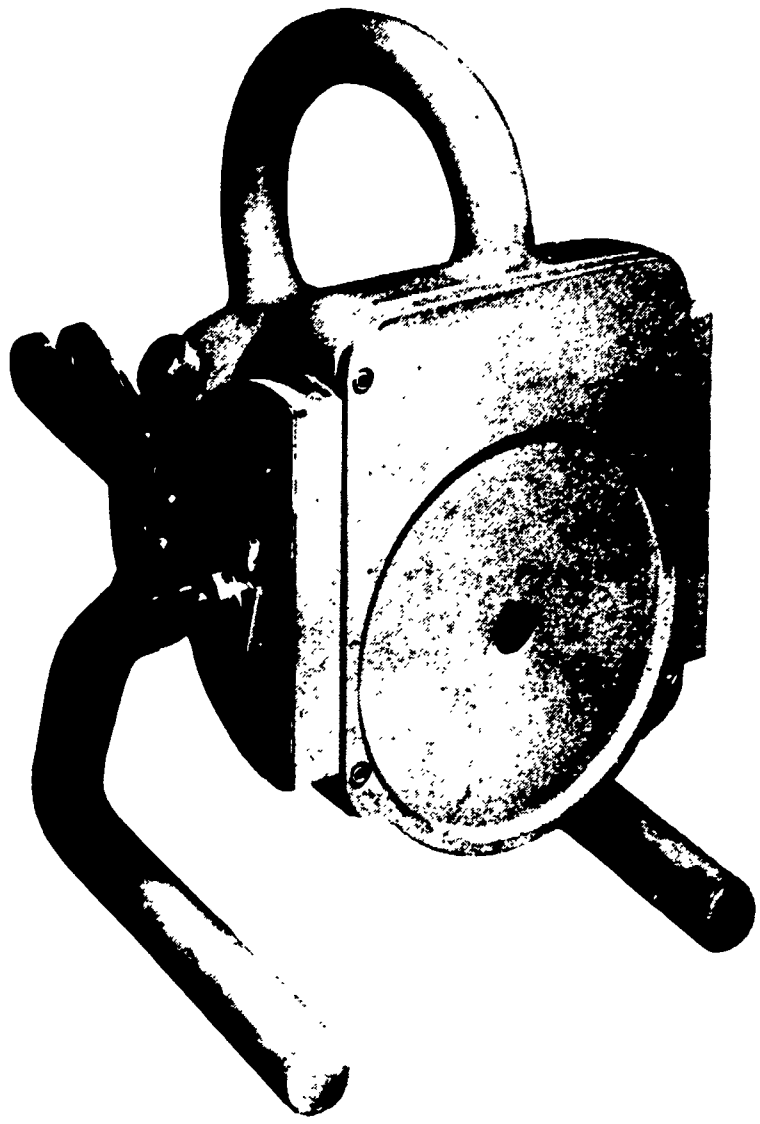
SOURCE IN "OFF" POSITION

Information Sheet
on
TYPICAL EXPOSURE DEVICES

Information
Sheet # 43



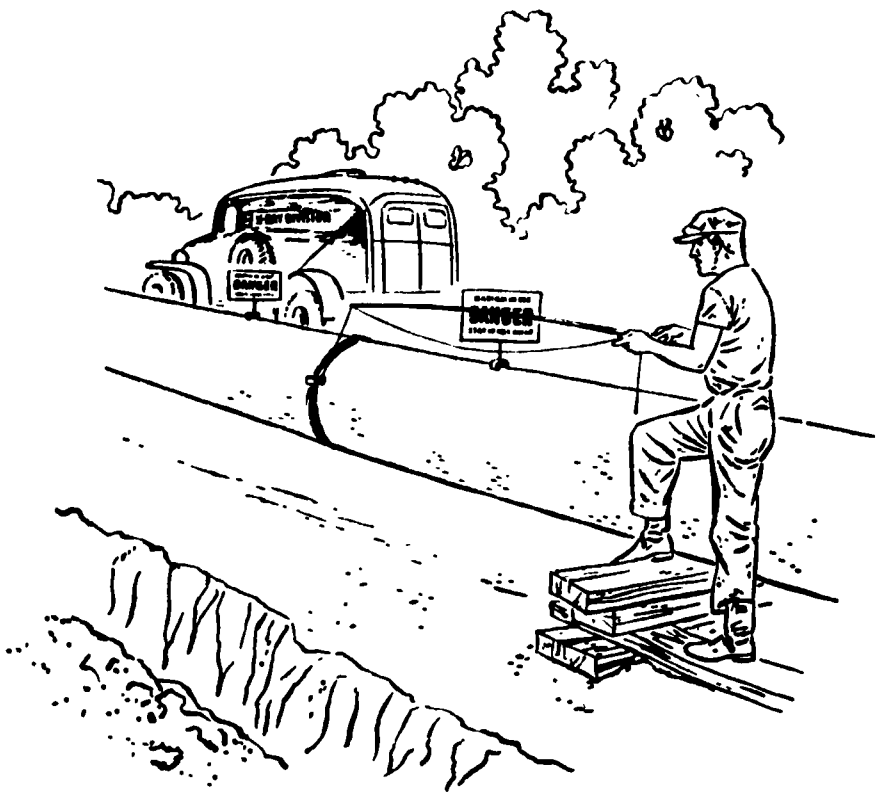
Philips Electronic Instruments



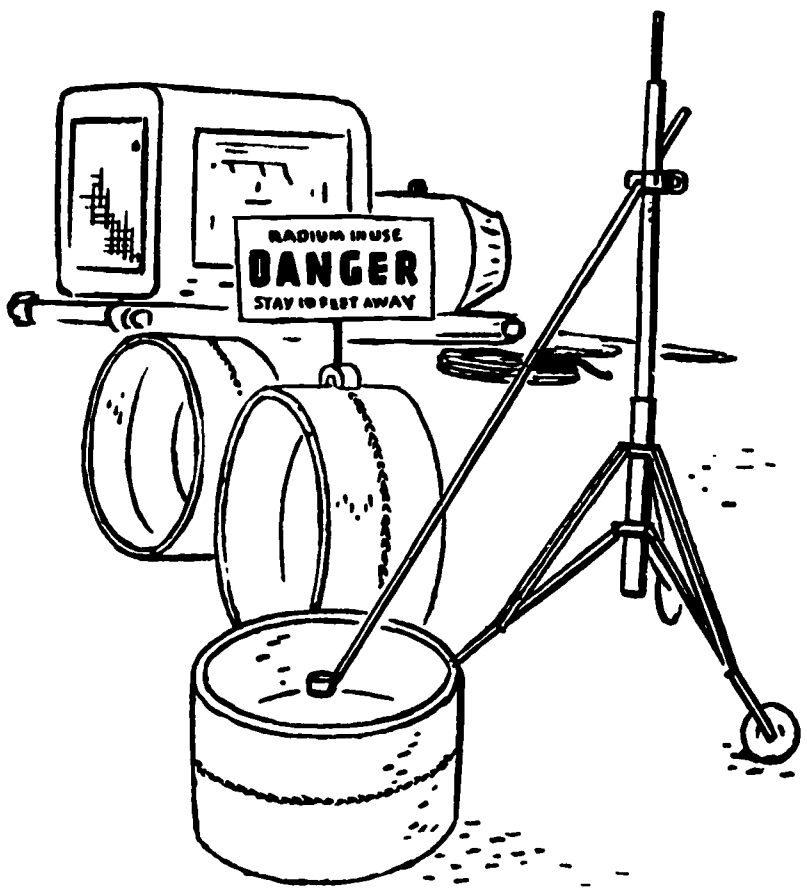
Electronic Instrument Division, The Budd Company

Information Sheet
on
EARLY METHODS OF RADIOGRAPHY

Information
Sheet # 44



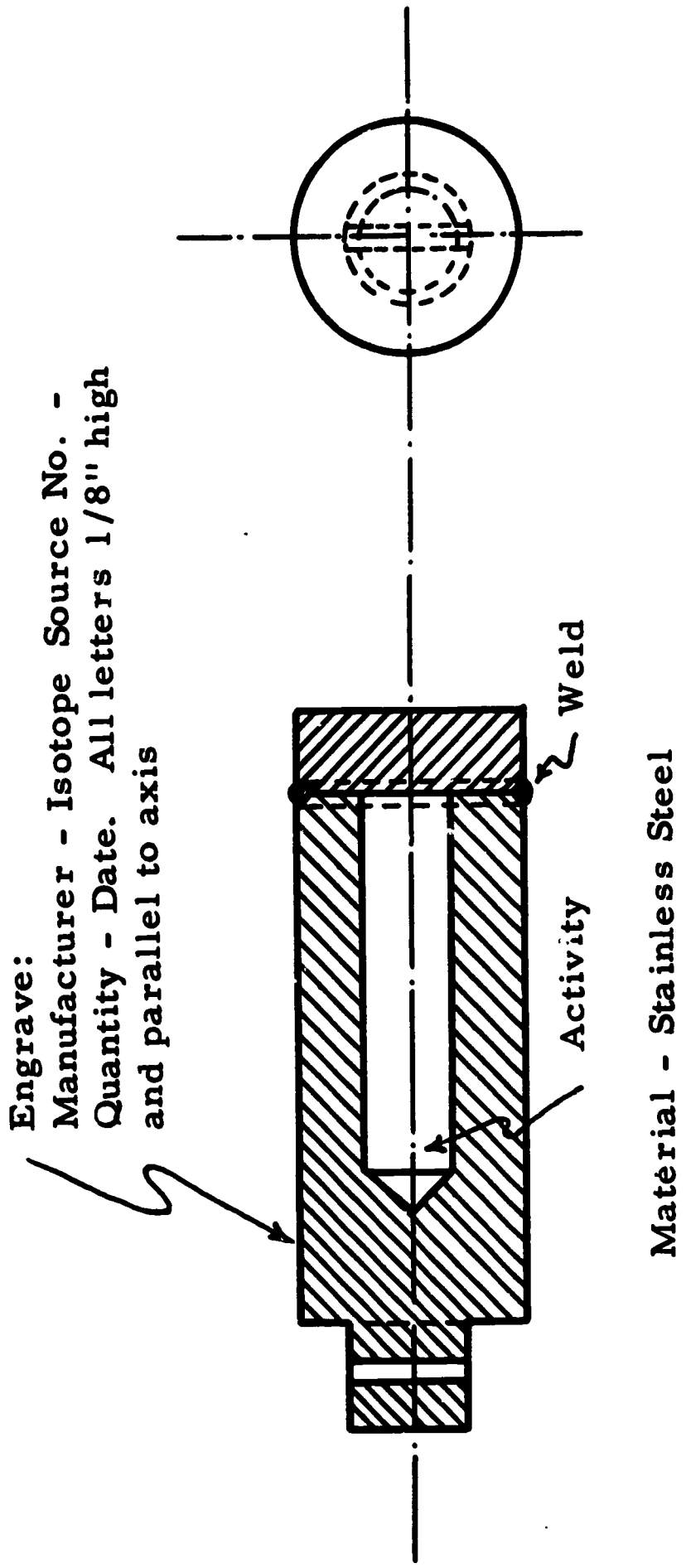
RADIUM "FISH POLE" METHOD



RADIUM SOURCE IN PAPER CUP

Information Sheet
on
TYPICAL GAMMA SOURCE CAPSULE

Information
Sheet # 45



Information Sheet
on
RELATIVE FILM DENSITIES

Information
Sheet # 46

140 KV 4 MA

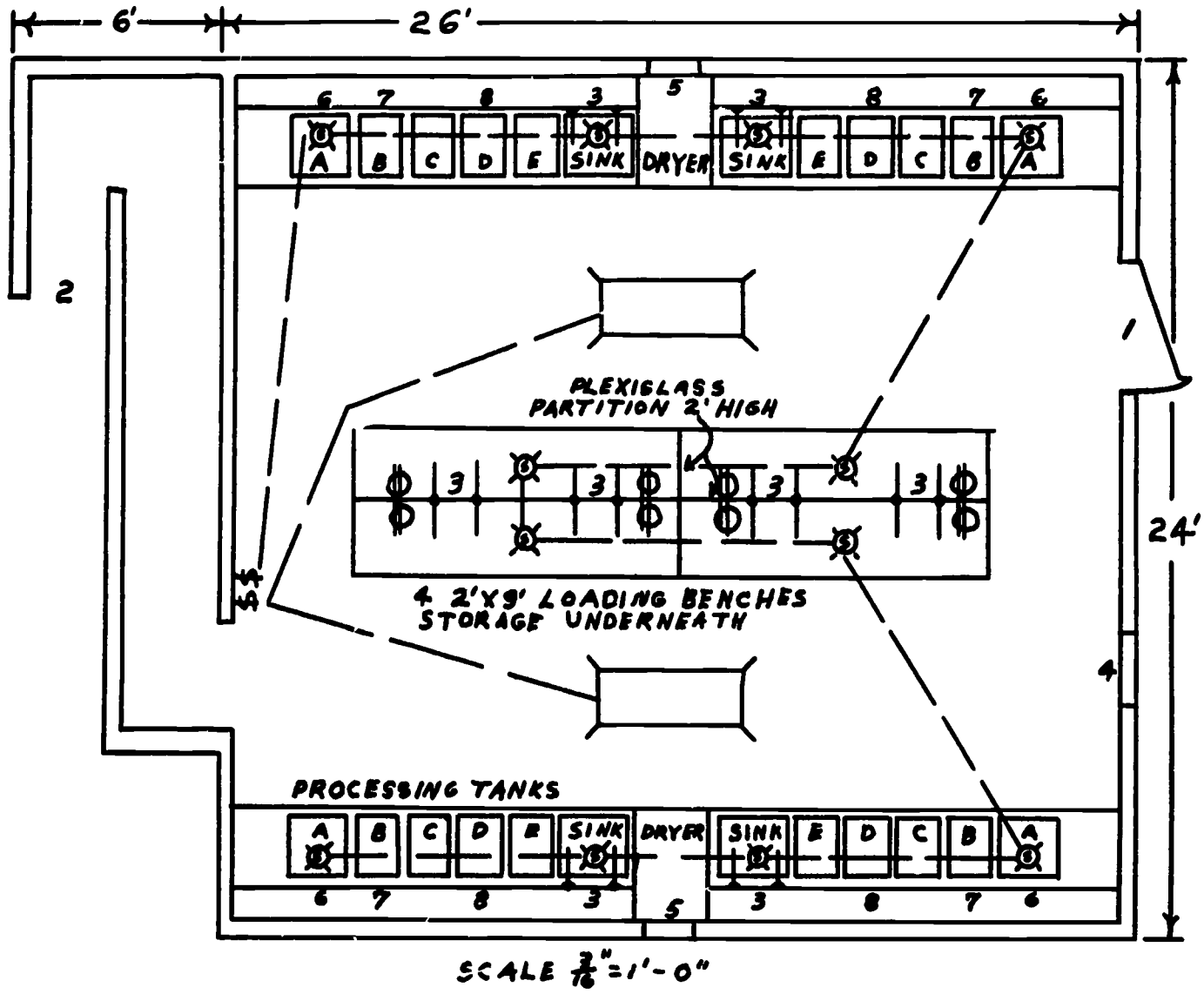
Aluminum	.00 5" Lead Density	. 010" Lead Density
1 inch	1. 06	. 72
7/8 inch	1. 27	. 80
3/4 inch	1. 45	. 93
5/8 inch	1. 74	1. 10
1/2 inch	2. 00	1. 25
3/8 inch	2. 18	1. 40

Comparison of vlatine

Film densities obtained at 140 kv 4 ma using . 005" lead screens compared with use of . 010" lead screens

Information Sheet
on
SUGGESTED DARKROOM LAYOUT PLAN

Information
Sheet # 47



SCALE $\frac{3}{16}$" = 1'-0"

Legend

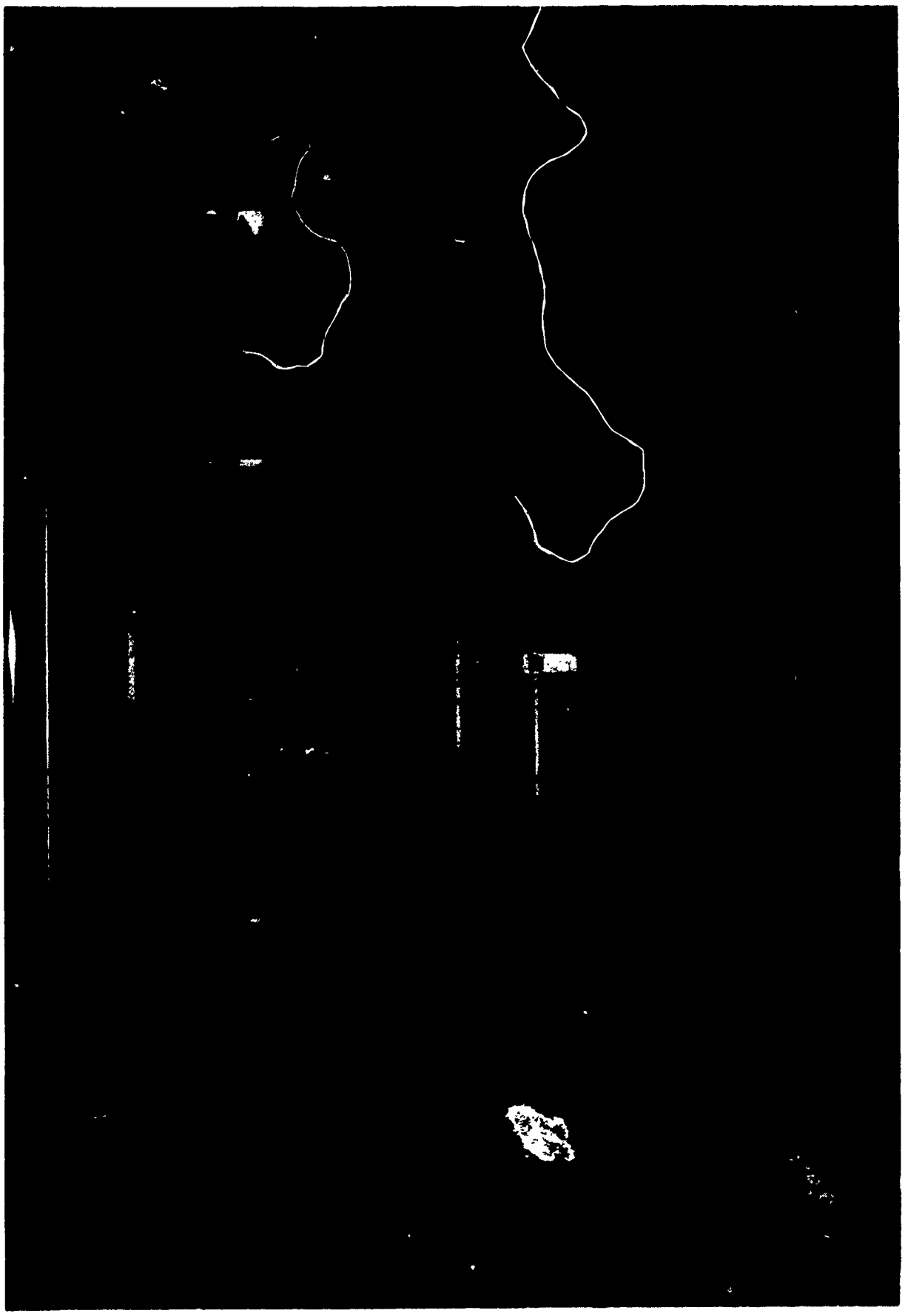
1. Door, 3'x6' 8", locked from inside, for moving equipment into room.
2. Labrynth
3. Film hanger
4. Air Duct
5. Film dryer exhausts
6. Timers
7. Chart boards
8. Illuminators
9. Indirect safelight lamps
10. A, B, C, D, E. Processing tanks

Direct safelight lamps

Note: Temperature control in darkroom is desirable for chemicals and film storage. (68 - 72 °F.) Film storage, waste bins, equipment storage under work benches.

Information Sheet
on
INTERIOR OF PORTABLE DARKROOM

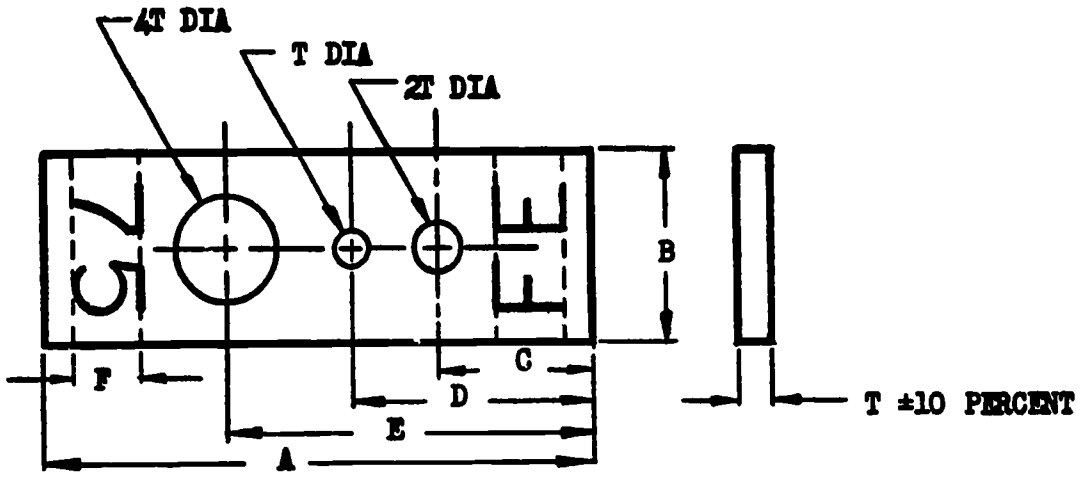
Information
Sheet # 48



Information Sheet
on
TYPICAL MILITARY PENETRAMETERS

Information
Sheet # 49

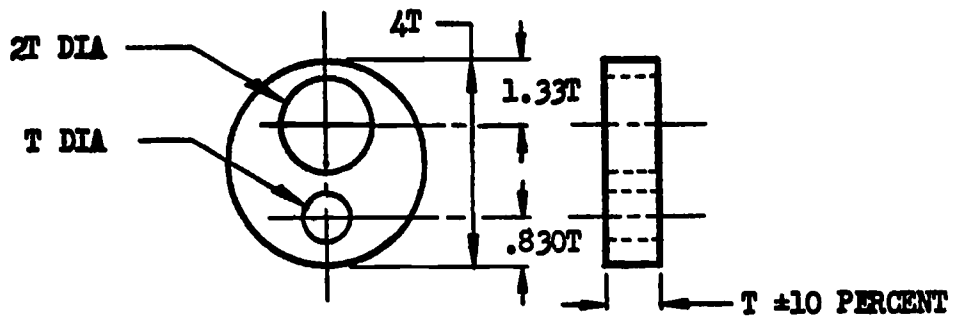
MIL-STD-453
29 OCTOBER 1962



T	INCREMENTS	A	B	C	D	E	F
.005-.020 INCL.	.0025	2.000	.500	.520	.800	1.150	.250
.025-.050 INCL.	.005	2.000	.500	.520	.800	1.150	.250
.060-.160 INCL.	.010	2.850	1.000	.800	1.250	1.900	.375

MIN PENETRAMETER THICKNESS .005 ±10 PERCENT
MIN DIAMETER FOR 1T HOLE .010 ±10 PERCENT
MIN DIAMETER FOR 2T HOLE .020 ±10 PERCENT
MIN DIAMETER FOR 4T HOLE .040 ±10 PERCENT

DESIGN FOR PENETRAMETER THICKNESSES UP TO AND INCLUDING 0.160



DESIGN FOR PENETRAMETER THICKNESSES OF 0.180 AND OVER MADE IN .020 INCREMENTS

SYMBOL	MATERIALS (SEE 4.2.2.2.3)
SS	STAINLESS STEEL
AL	ALUMINUM
FE	STEEL
MG	MAGNESIUM
CU	COPPER
TI	TITANIUM

ALL DIMENSIONS IN INCHES.
HOLES SHALL BE TRUE AND NORMAL TO THE SURFACE OF THE PENETRAMETER. DO NOT CHAMFER.
TOLERANCES ON PENETRAMETER THICKNESSES AND HOLE DIAMETERS SHALL BE ±10 PERCENT OR 1/2 OF THE THICKNESS INCREMENT BETWEEN PENETRAMETER SIZES, WHICHEVER IS SMALLER.

Information Sheet
on
ASME PENETRAMETERS (GAMMA)

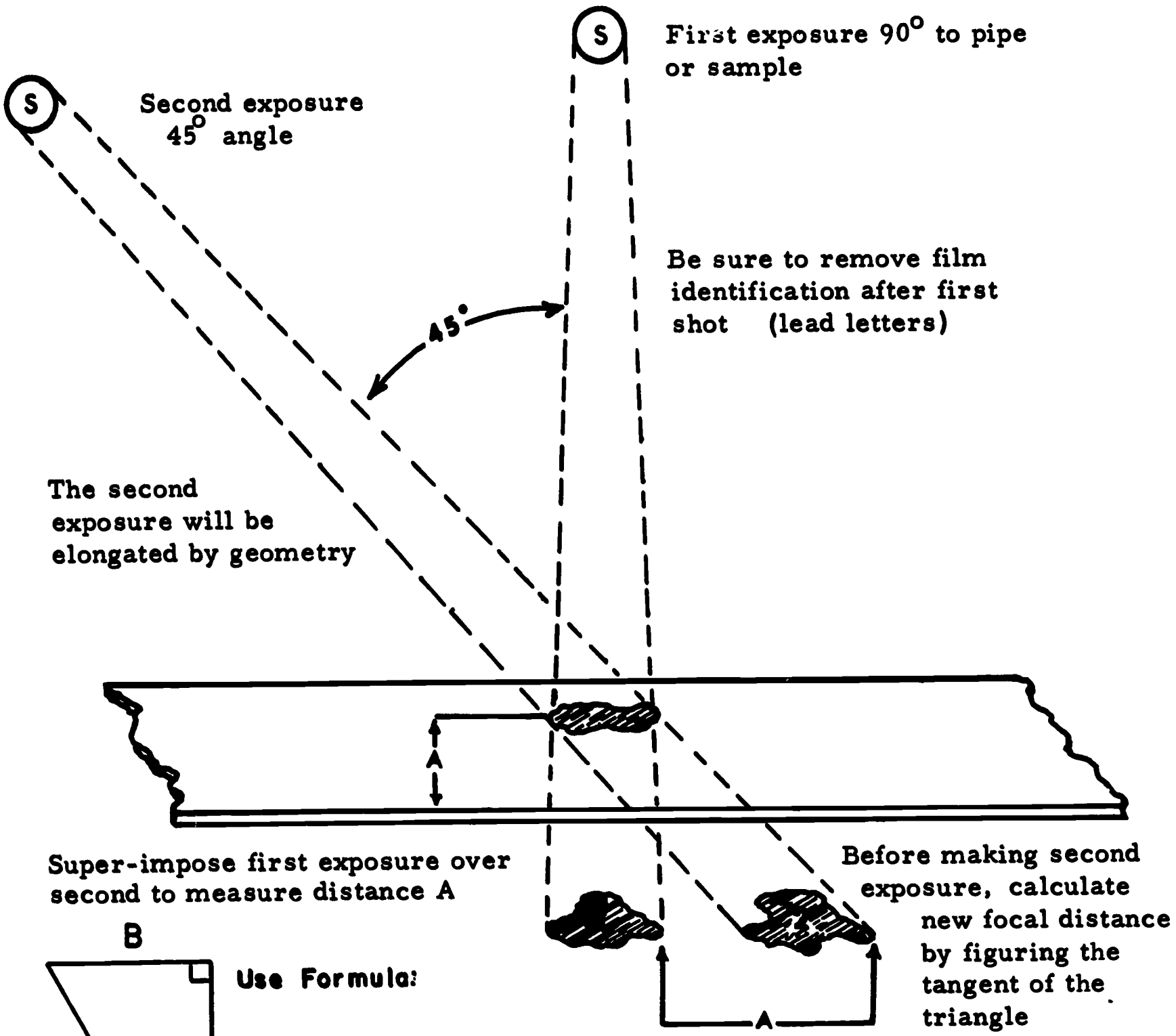
Information
Sheet # 50

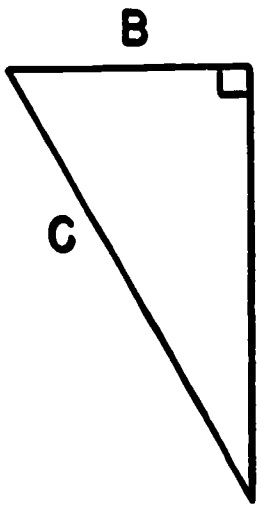
STEEL THICKNESS (INCHES)	PENETRAMETER NUMBER
Up to 1/4" incl.	5
1/4 to 3/8	7
3/8 to 1/2	10
1/2 to 5/8	12
5/8 to 3/4	15
3/4 to 7/8	17
7/8 to 1. 0	20
1. 0 to 1 1/4	25
1 1/4 to 1 1/2	30
1 1/2 to 2. 0	35
2. 0 to 2. 5	40
2. 5 to 3. 0	45
3. 0 to 3. 5	50

Information Sheet
on
TECHNIQUE FOR FAULT LOCATION

Information Sheet # 51

Should one radiograph show a flaw, it's approximate location in the parent metal can be determined thus:



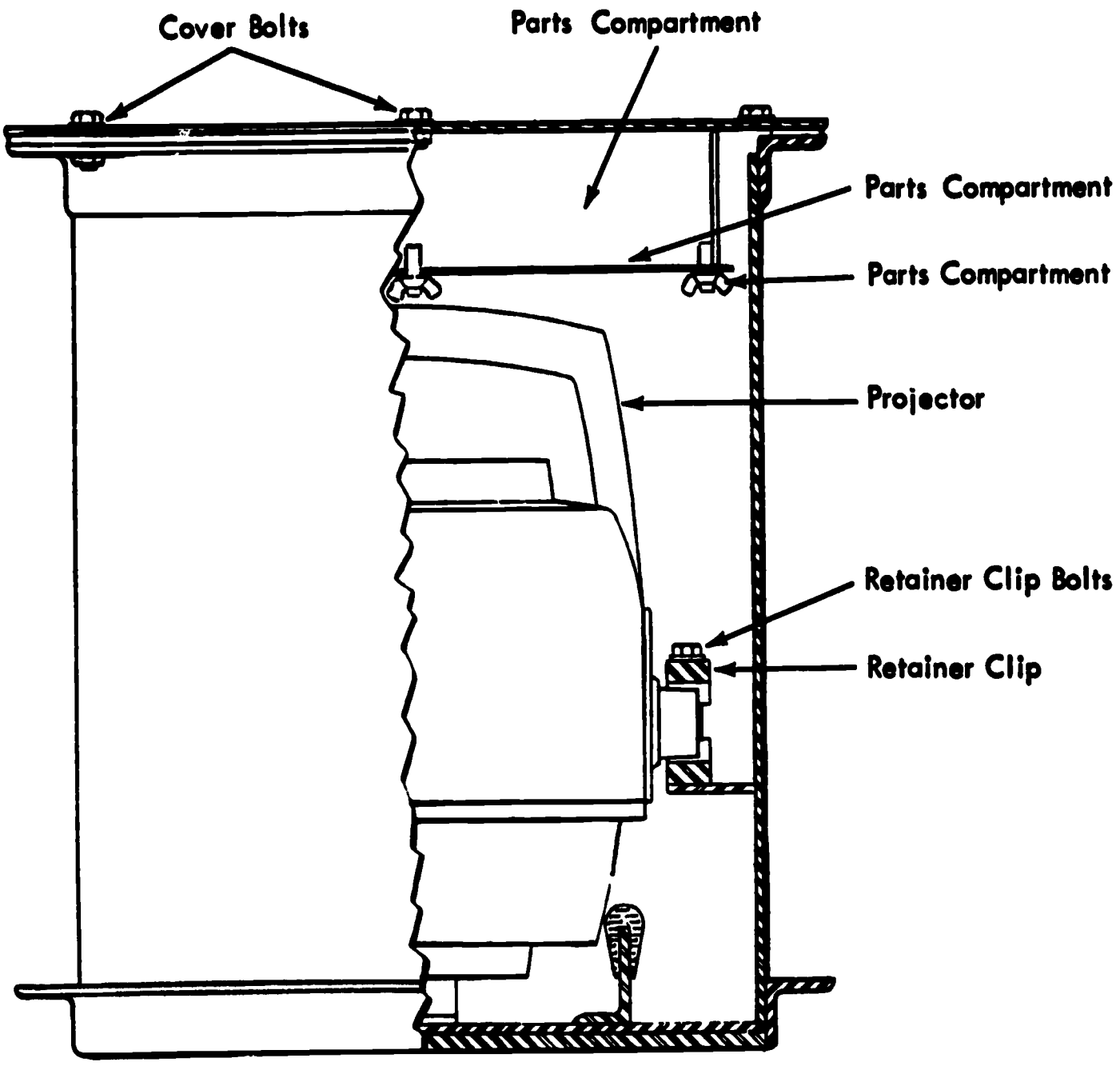


Use Formula:

$$B^{\text{square}} \text{ plus } C^{\text{square}} = \sqrt{B^2 C^2}^{D}$$

Information Sheet
on
TYPICAL SHIPPING CONTAINER

Information
Sheet # 52



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PRACTICAL PROCEDURES OF MEASUREMENT, 48 minutes, 16 mm, sound, AEC film list, Popular Level, AEC Film Library

LIVING WITH RADIATION, 28 minutes, 16 mm, sound (Separation/ Distance factors, film badges, shielding, decontamination procedures) AEC filmlist, Popular Level, AEC Film Library

INVISIBLE BULLETS - CHALLENGE SERIES, 29 minutes, 16 mm, sound, AEC film list, Popular Level, 1962

ISOTOPES -- EXCURSION IN SCIENCE, 20 minutes, 16 mm, sound, AEC film list, Professional Level, AEC Film Library, 1959

ELEMENTS OF ELECTRICAL CIRCUITS, 11 minutes, 16 mm, sound, Pennsylvania State University, University Park, Pa.

CHEMISTRY OF IRON AND STEEL, 14 minutes, 16 mm, sound, U. S. Steel Corp.

SEMI-FINISHED STEEL, 8 minutes, 16 mm, sound, U. S. Steel Corp.

HOT ROLLING STEEL SHEETS, 8 minutes, 16 mm, sound, U. S. Steel Corp.

SHOP DRAWINGS, 22 minutes, 16 mm, sound, Pennsylvania State University, University Park, Pa.

THE INSIDE STORY, 32 minutes, 16 mm, sound, Eastman Kodak Company, Rochester, N. Y.

GLOSSARY

"A": Symbol for mass number, that is, the number of the protons in the nucleus; hence the number of positive charges on the nucleus. The mass number is approximately equal to the atomic weight. For example: "A" is 1 for hydrogen, 2 for deuterium and 235 for uranium.

ABSORPTION: Act or process of being absorbed - being taken in

ACTUATING: Putting into action

A.E.C.: U.S. Atomic Energy Commission

ALPHA RAY: Stream of fast-moving helium nuclei (alpha particles). A strongly ionizing and weakly penetrating radiation.

ANGSTROM UNIT: A minute unit of length equal to one ten-thousandth of a micron or one one-hundred millionth of a centimeter, used in expressing the length of light waves.

ANODE: Positive electrode; electrode to which negative ions are attracted

A.S.M.E.: American Society of Mechnical Engineers

A.S.T.M.: American Society for Testing Materials

ATOM: The basic building block of nature and the smallest particle that can enter into a chemical reaction. The atom can be subdivided and consists of an inner core or nucleus make up by neutrons and protons, surrounded by electrons which rotate around this nucleus like planets around the sun

ATOMIC NUMBER: The number of protons (positively charged particles) found in the nucleus of an atom. All elements have different atomic numbers. The atomic number of hydrogen is 1, that of oxygen 8, iron 26, lead 82, uranium 92. The atomic number is also called charge number and is usually denoted by Z.

ATOMIC WEIGHT: The atomic weight is approximately the sum of the number of protons and neutrons found in the nucleus of an atom. This sum is also called mass number. The atomic weight of oxygen, for example, is approximately 16, with most oxygen atoms containing 8 neutrons plus 8 protons. Aluminum is 27 - it contains 14 neutrons and 13 protons.

ATTENUATION: The process by which a beam of radiation is reduced in intensity when passing through some material.

AUTORADIOGRAPHY: Self-portraits of radioactive sources made by placing the radioactive material next to photographic film. The radiations fog the film leaving an image of the source. It was such self-portraits that led to the discovery of radioactivity.

AVERAGE LIFE: (MEAN LIFE) The average of the individual lives of all the atoms of a particular radioactive substance. It is 1.443 times the radioactive half-life.

A. W. S.: American Welding Society

BACKGROUND RADIATION: This is due to cosmic rays from outer space, small amounts of radioactive substances present in our bodies and in many of the materials surrounding us.

BACKSCATTER: The deflection of radiation by scattering processes through angles greater than 90 degress with respect to the original direction of motion.

BETA PARTICLE: Charged particle emitted from the nucleus of an atom and having a mass and charge equal in magnitude to those of the electron.

BINDING ENERGY: The energy which holds the neutrons and protons of an atomic nucleus together.

BREMSSTRAHLUNG: Secondary photon radiation produced by deceleration of charged particles passing through matter.

CALIBRATION: Determination of variation from standard, or accuracy of a measuring instrument to ascertain necessary factors.

CASSETTE: A holder for film

CATHODE: Negative electrode; electrode to which positive ions are attracted

CESIUM -137: An isotope of the element cesium having a mass number of 137. One of the important fission products and a constituent of fallout. It has a half-life of 33 years.

CHAMBER, IONIZATION: Ion chambers are filled with gas (often air) and are provided with two oppositely charged electrodes. They differ from Geiger counters in simply collecting the electric charge on the ions that radiation produces in the gas.
The collected ions produce a minute electrical current, which may be detected directly by a sensitive electrometer or may be amplified to give a meter reading. This current is a measure of the radiation.

COBALT - 60: A radioactive isotope of the element cobalt. Cobalt-60 is important as one of the least expensive sources of gamma radiation and is used widely in radiography.

COLLIMATOR: A device for confining the elements of a beam within an assigned solid angle (A device for directing the useful radiation into a more or less parallel beam.)

COMPATIBLE: Capable of coexisting in harmony

COMPTON EFFECT: The glancing collision of a gamma ray with an electron. The gamma ray gives up part of its energy to the electron. The name is taken from the discoverer, Dr. Arthur Compton .

CONTAMINATION: Disposition of radioactive material, generally in a finely divided or liquid form in any place where it is not desired and will produce a hazard to personnel.

CORPUSCULAR RADIATION: A general term given those types of radiation which consist of particles such as alpha and beta radiation.

COSMIC RADIATION: Extremely high energy radiation consisting of both particles and rays which originate out in space and constantly bombard the earth. Cosmic radiation has great penetrating ability in all materials.

COUNTER, PROPORTIONAL: Gas filled radiation detection tube in which the pulse produced is proportional to the number of ions formed in the gas by the primary ionizing particle.

CURIE: That quantity of radioactive nuclide disintegrating at the rate of 37 billion atoms per second (abbreviated: c.)

DECAY CURVE: A curve showing the relative amount of radioactive substance remaining after any time interval.

DECAY, RADIOACTIVE: When a radioactive atom disintegrates it is said to decay. What remains is a different element. An atom of polonium decays to form lead, ejecting an alpha particle in the process.

DECONTAMINATION: The removal, by physical or chemical means, of unwanted radioactive material from a surface.

DENSITOMETER: Instrument utilizing a photocell to determine the degree of darkening of developed photographic film.

DENSITY (Photographic): Denotes the degree of darkening of photographic film. (Physics), Ratio of the mass of a homogeneous portion of matter to its volume.

DICHROIC: Having the property of presenting colors in two different directions, by transmitted light.

DISINTEGRATE: When a radioactive atom gives off its excess energy in the form of radiation it is said to disintegrate.

DOSE, PERMISSIBLE: The amount of radiation which may be received by an individual within a specified period with expectation of no significantly harmful result to himself.

DOSE RATE: The radiation dose delivered to the body in a certain period of time. Rate of any radiation energy absorption per gram of any material.

DOSE RATE METER: Any instrument which measures radiation dose rate.

DOSIMETER: Instrument used to detect and measure an accumulated dosage of radiation; in common usage it is a pencil-sized ionization chamber with a built-in self reading electrometer; used for personnel monitoring.

DROSS: The scum or waste matter from molten ore or metal.

ELECTROMETER: Electrostatic instrument for measuring change of electric potential of charged electrodes resulting from ionization produced by radiation.

ELECTRON: Negatively charged particle which is a constitutent of every neutral atom.

ELECTRON, SECONDARY: An electron ejected from an atom, molecule, or surface as a result of a collision with a charged particle or photon.

ELECTROSCOPE: Instrument for detecting the presence of electric charges by the deflection of charged bodies.

ELEMENT: A basic substance consisting of a "family" of naturally occuring isotopes. For example, hydrogen, lead and oxygen are elements. All atoms of an element contain a definite number of protons and thus have the same atomic number.

ENCAPSULATED: Enclosed in a capsule (a small container)

ENERGY: Capacity for doing work.

ENVIRONMENTAL: Related to the external conditions and influences affecting the life and development of an organism.

EROSION: The act of being eaten or worn away.

EXTERNAL RADIATION: Exposure to radiation from radioactive sources located outside of the body.

FILM BADGE: A pack of photographic film used for approximate measurement of radiation exposure for personnel monitoring purposes. The badge may contain a filter which shields part of the film from certain types of radiation.

FILM CONTRAST: The slope or steepness of the characteristic curve of the film. It depends upon the type film, the processing it receives, and the density.

FISSION, NUCLEAR: A nuclear transformation characterized by the splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. The division or splitting of an atomic nucleus releasing very great amounts of heat and radioactivity.

FLAW: A crack; a gap; a defect; a fault.

FLUOROSCOPY: The process of examining an object by direct observation of the fluorescence of a screen caused by radiation transmitted through the object.

FOCAL SPOT (X-rays): The part of a target of the X-ray tube which is struck by the main electron stream.

GAMMA RADIATION: Short wavelength electromagnetic radiation of nuclear origin with a range of wavelengths from about 10-8 to 10-11 cm, emitted from the nucleus.

GEIGER COUNTER: Highly sensitive gas-filled radiation-measuring device which operates at voltages sufficiently high to produce avalanche ionization.

HALF-LIFE RADIOACTIVE: Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life.

HALF-THICKNESS (HALF VALUE LAYER): The thickness of any particular material necessary to reduce the intensity of an X-ray or gamma ray beam to one-half its original value.

HEALTH PHYSICS: A name given to that branch of radiation science concerned with the protection of personnel from radiation.

INCLUSIONS: Internal discontinuities commonly encountered in radiographic work such as trapped gas or blowholes and porosity; slag; or other foreign bodies.

INTENSITY: Rate of radiation energy passing through unit surface area.

ION: Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.

IONIZATION: The process or the result of any process by which a neutral atom or molecule acquires either a positive or a negative charge.

IONIZATION CHAMBER: A gas filled region in an electrical field between electrodes across which a potential difference is applied.

ISODOSE CHART: Chart showing the distribution of radiation in a medium by means of lines or surfaces drawn through points receiving equal doses.

ISOTOPE: One of several nuclides having the same number of protons in their nuclei, and hence having the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element.

MEV: A unit of nuclear energy equal to 1 million electron volts.

MICROCURIE: A measure of radioactive material. One-millionth of a curie.

MILLICURIE: A measure of radioactive material. One-thousandth of a curie.

MILLIROENTGEN: (mr) A submultiple of the roentgen equal to one one-thousandth (1/1,000) of a roentgen.

MODERATOR: Material used in a nuclear reactor to moderate (slow down) neutrons from the high energies at which they are released.

MONITOR: A radiation detector used to determine whether an area is safe for workers.

MONITORING: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

NONDESTRUCTIVE TESTING: Includes all possible methods of detection or measurement of the properties or performance capabilities of materials, parts, assemblies, or structures, which do not impair their serviceability.

NEUTRON: Elementary nuclear particle with a mass approximately the same as that of a hydrogen atom and electrically neutral. Neutrons are divided into sub-classifications: thermal-.025 ev, epithermal-0.1 ev to 100 ev; slow-less than 100 ev; intermediate, 10^2 to 10^5 ev; fast, greater than .1 mev.

NUCLEUS: That part of an atom in which the total positive electric charge and most of the mass are concentrated.

PAIR PRODUCTION: An absorption process for X- and gamma radiation in which the incident photon is annihilated in the vicinity of the nucleus of the absorbing atom with subsequent production of an electron and positron pair.

PENETRAMETER: A standard test piece superimposed on the specimen to be radiographed to determine radiographic sensitivity by the visibility of the test piece on the finished radiograph.

PHOTOELECTRIC EFFECT: Occurs when an electron is knocked out of an atom by a light ray or gamma ray. This effect is used in an "electric eye". Light falls on a sensitive surface, knocking out electrons which can then be detected.

PHOTON: A quantity of electromagnetic energy whose value in ergs is the product of its frequency in cycles per sec. and Planck's constant. (a natural constant of proportionality relating the frequency of a quantum of energy to the total energy of the quantum.)

PLATEAU: As applied to radiation detector chambers, the level portion of the counting rate-voltage curve where changes in operating voltage introduce minimum changes in the counting rate.

PLATEAU SLOPE; RELATIVE: The relative increase in the number of counts as a function of voltage expressed in percentage per 100 volts increase above the Geiger threshold.

POSITRON: Particle equal in mass to the electron and having an equal but opposite charge.

PROTON: Elementary nuclear particle with a positive electric charge equal numerically to the charge of the electron and a mass of 1.007594 units.

QUANTUM THEORY: Concept that energy is radiated intermittently in units of definite magnitude called quanta, and absorbed in a like manner.

RAD: The unit of absorbed dose, which is 100 ergs/gram. The rad is a measure of the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest.

RADIATION: The emission and propagation of energy through space or through a material medium in the form of waves.

RADIATION, BACKGROUND: Radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radiation is always present.

RADIOACTIVITY: Process whereby certain nuclides undergo spontaneous disintegration in which energy is liberated, generally resulting in the formation of new nuclides. The process is accompanied by the emission of one or more types of radiation, such as alpha particles, and gamma photons.

RADIOCHEMISTRY: That phase of chemistry concerned with the properties and behavior of radioactive materials.

RADIOGRAPHY: The making of radiographs or shadow images on photographic emulsion by the passage of X-rays or gamma rays through a specimen or object onto a film which, after development, provides a permanent visible record of the internal condition of the specimen or object. The shadow image is the result of the differential attenuation of the radiation in its passage through the object being radiographed.

RADIOISOTOPES: Another name for radioactive materials.

RADIUM: One of the earliest known naturally radioactive elements. It is far more radioactive than uranium and is found in the same ores.

RBE DOSE: Biological dose.

REACTOR: A nuclear reactor is an "atomic furnace". In a reactor, nuclei of the fuel are burned (i.e., undergo controlled fission) under the influence of neutrons, in a chain reaction. This energy is removed as heat which may be used to make steam for driving steam engines and to produce electricity. The moderator for the first reactor was piled-up blockes of graphite. Thus, a nuclear reactor was formerly referred to as a pile. Reactors are usually classified now as research, test, process heat and power, depending on their principal function. No workable design for a controlled fusion reactor has yet been devised.

REM: A measure of the dose to body tissue of any ionizing radiation in terms of its estimated biological effect relative to a dose of Ir. of X-rays.

RESOLVING TIME, COUNTER: The minimum time interval between two distinct events which will permit both to be counted. It may refer to an electronic circuit, to a mechanical indicating device, or to a counter tube.

ROENTGEN: The quantity of X or gamma radiation such that the associated corpuscular emission per .001293 grams of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign.

ROENTGEN EQUIVALENT MAN (REM): That quantity of any type ionizing radiation which when absorbed by man produces an effect equivalent to the absorbtion by man of one roentgen of X or gamma radiation (400 kv)

SCALER: An electronic device which registers current pulses received over a given time interval.

SHIELD: A body of material used to prevent or reduce the passage of particles of radiation.

SOURCE: Any substance which emits radiation. Usually refers to a piece of radioactive material conveniently packaged for scientific or industrial use.

URANIUM: The heaviest naturally occurring radioactive element, atomic number 92. Pure uranium is an alpha radiation emitter and an internal radiation hazard. Two of the radioisotopes of uranium are fissionable and can be used as fuel in reactors. Uranium-235 is the one most commonly used.

WELDMENT: A unit formed by welding together an assembly of pieces.

X-RAYS: Penetrating electromagnetic radiations having wavelengths shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum.

"Z": Symbol for atomic number. An element's atomic number is the same as the number of protons found in one of its nuclei. All isotopes of a given element have the same "Z" number. Z=92 for uranium isotopes.

Additional useful terminology may be found in the following listed publications:

Health Physics Handbook, Ft. Worth, Tex. General Dynamics Corp. 1963

101 Atomic Terms and What They Mean, Linden, N.J., Esso Research and Engineering Company, (Booklets free on request)

Radiological Health Handbook, Washington: Office of Technical Services, Department of Health, Education, and Welfare, 1957